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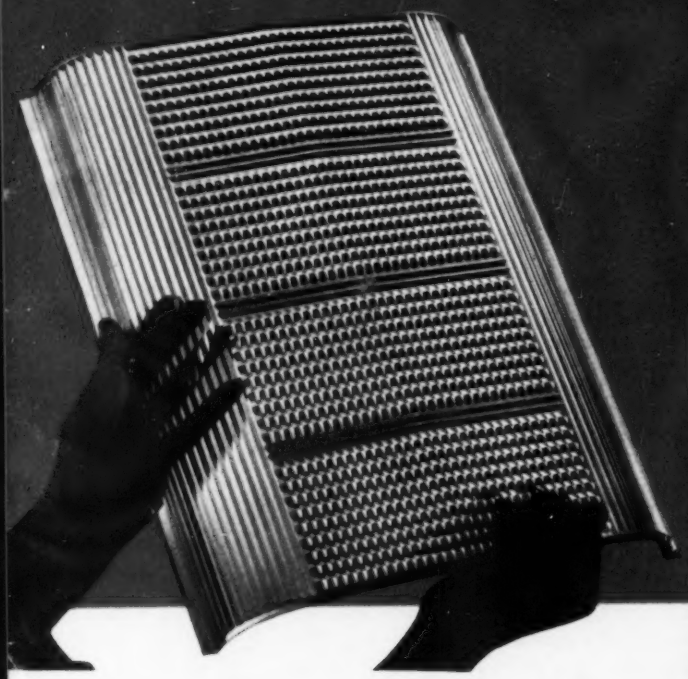

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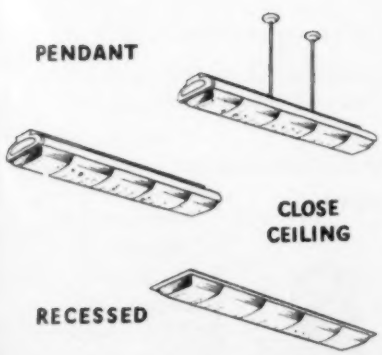

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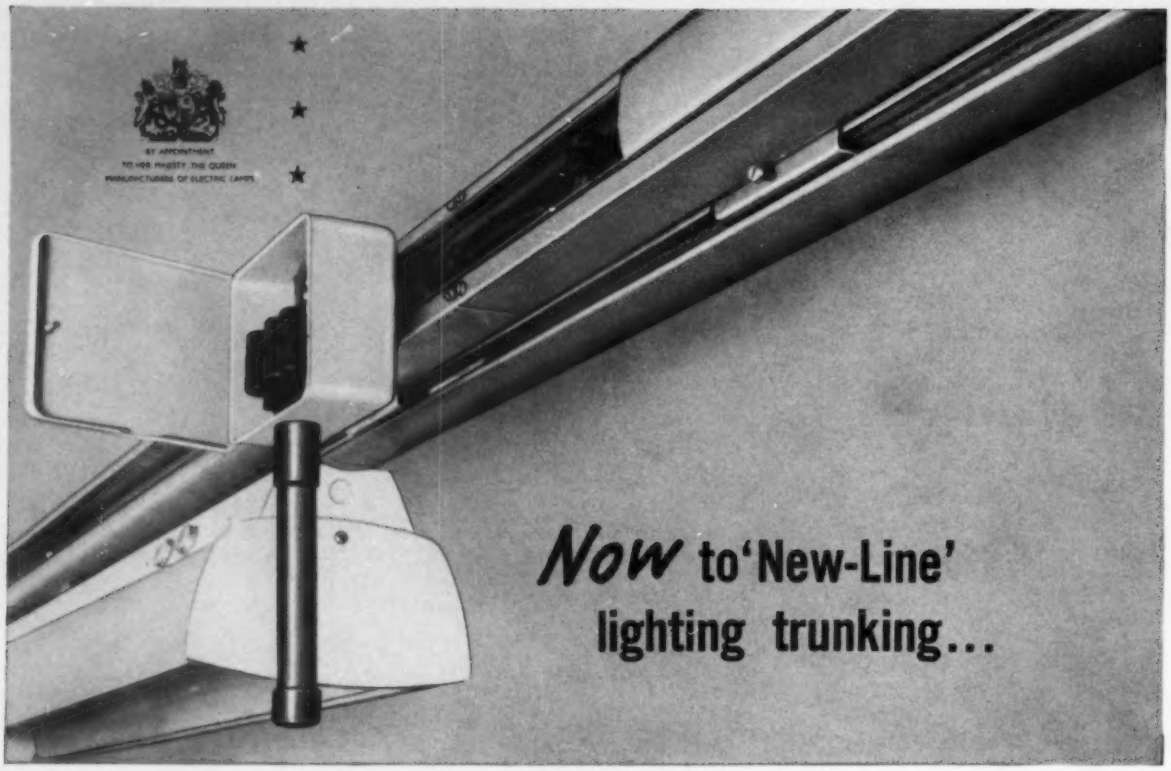

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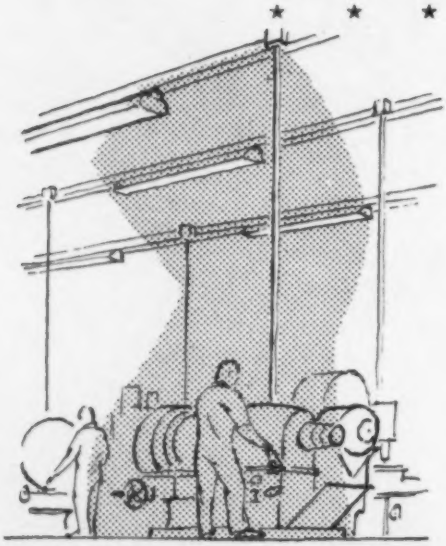

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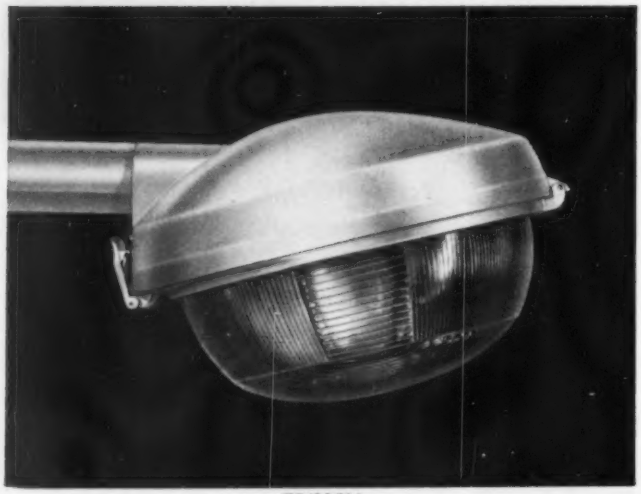

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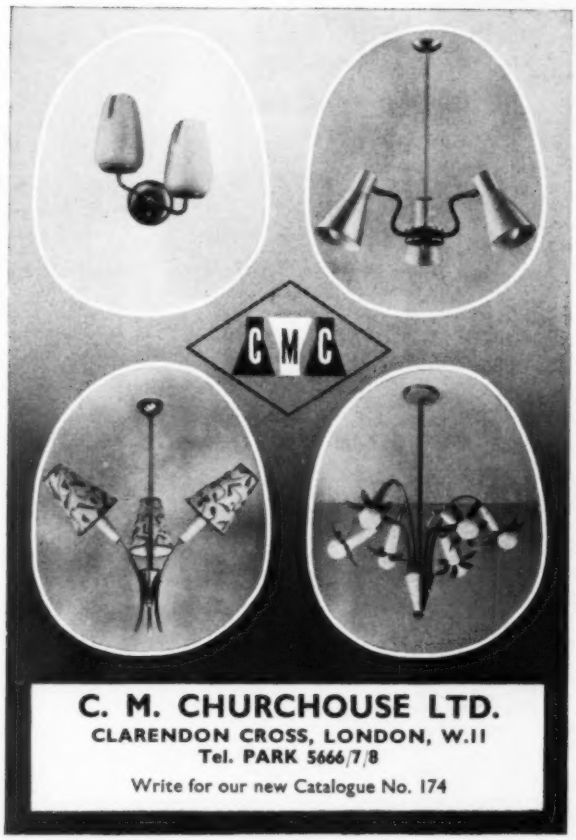

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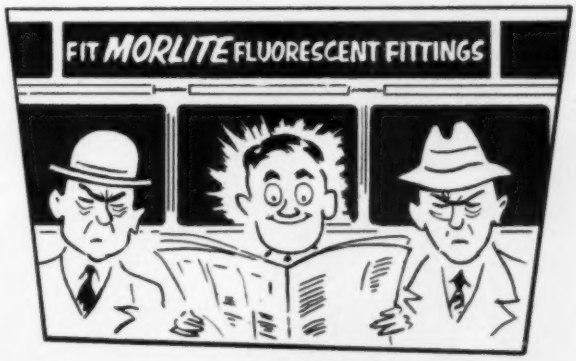

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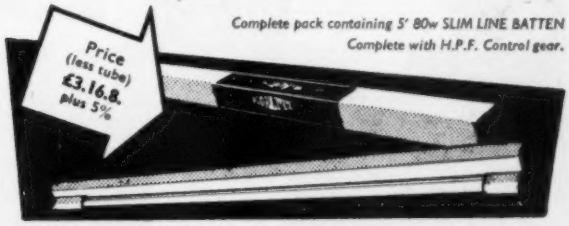

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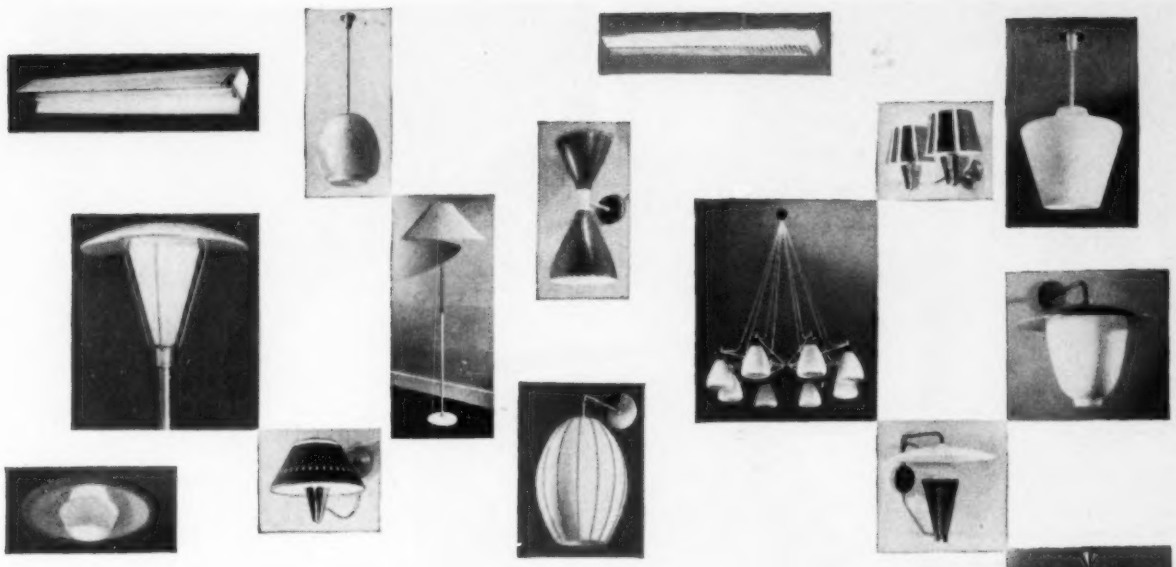

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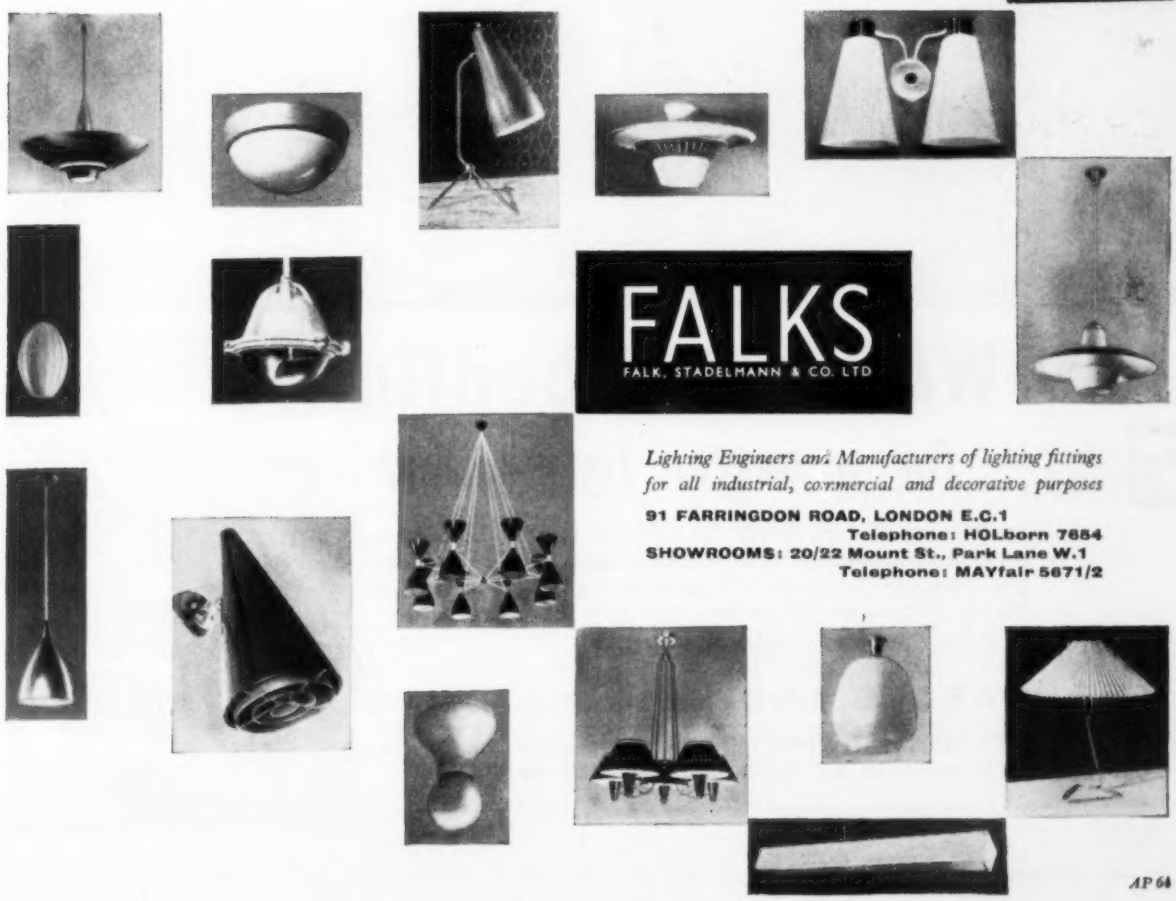

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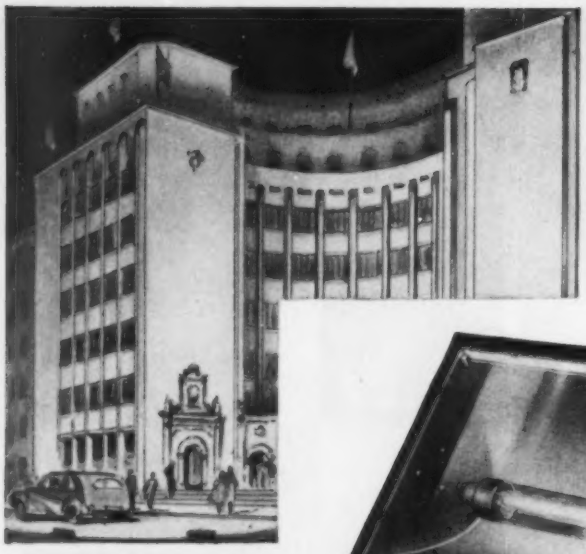

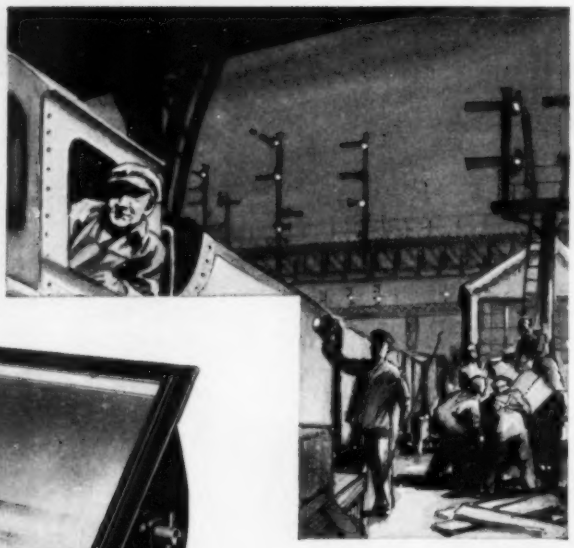

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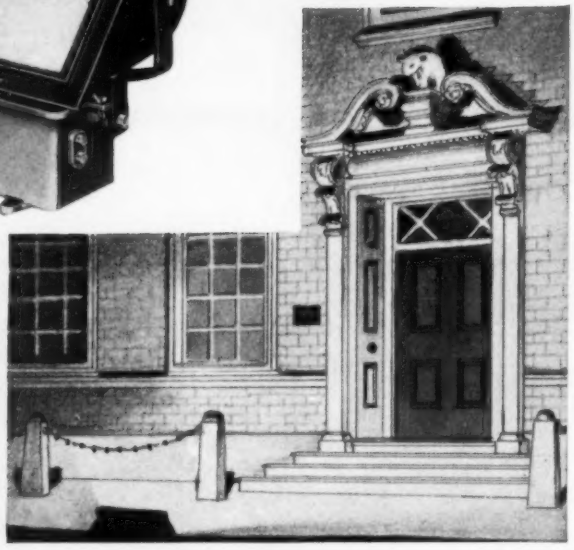

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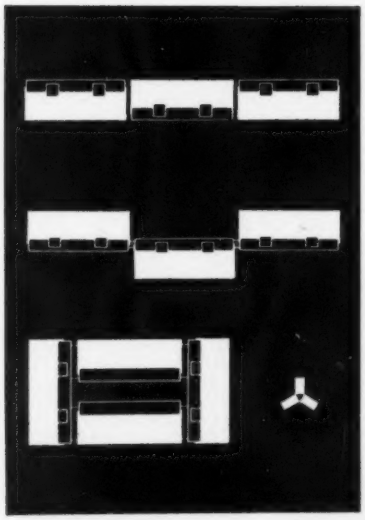

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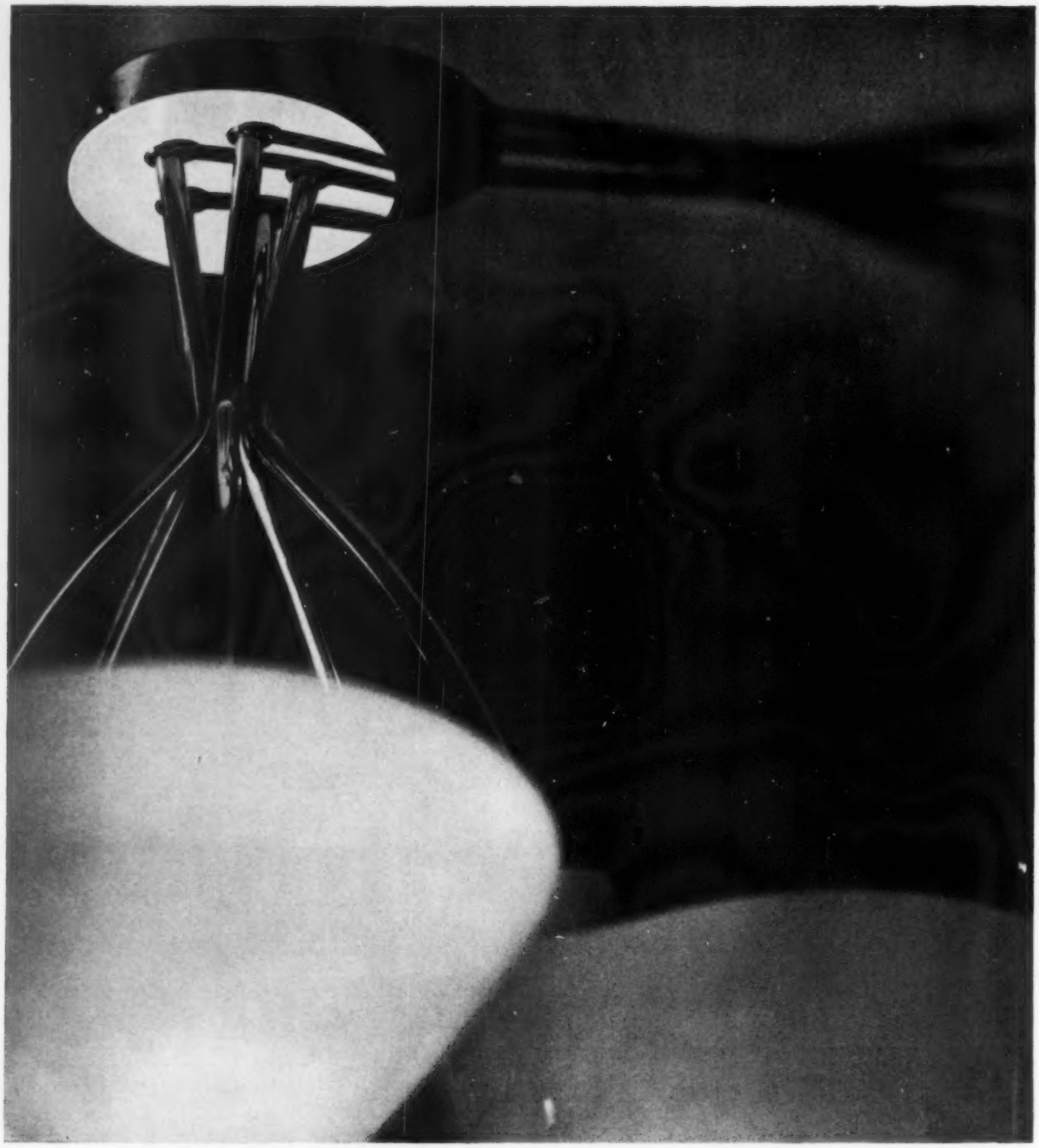

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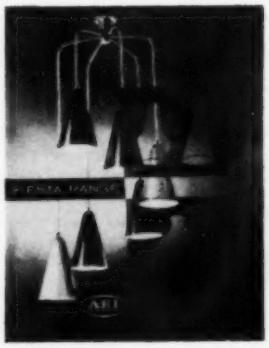

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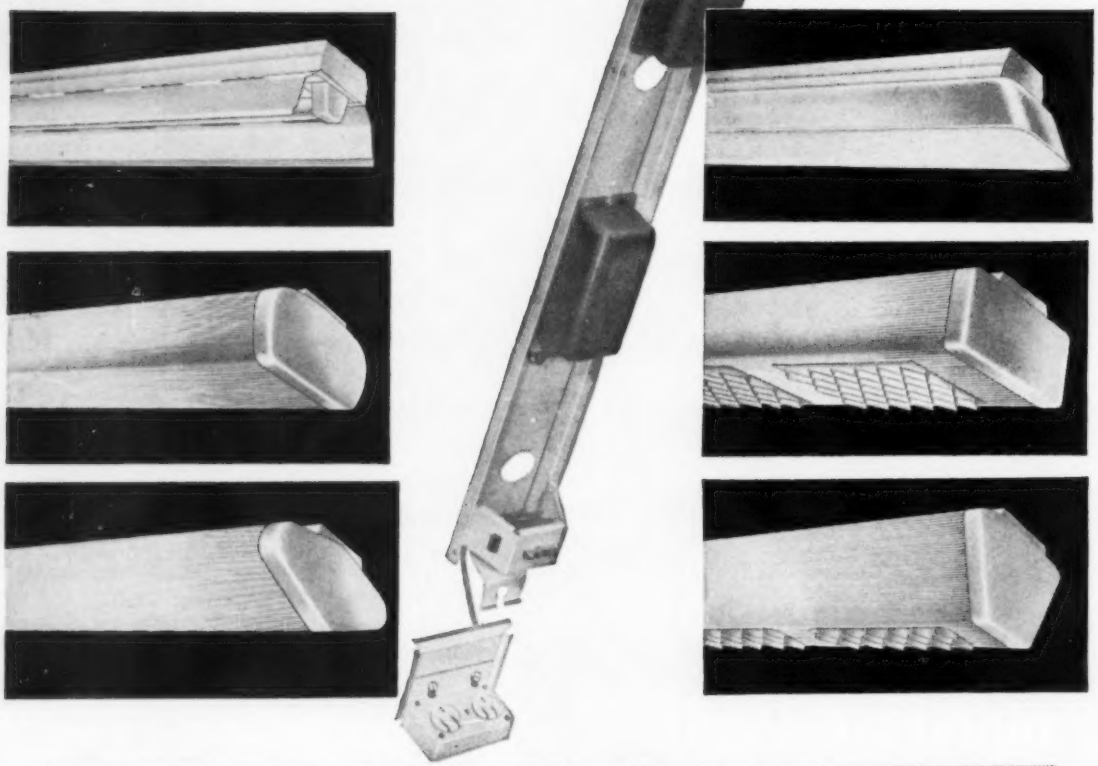

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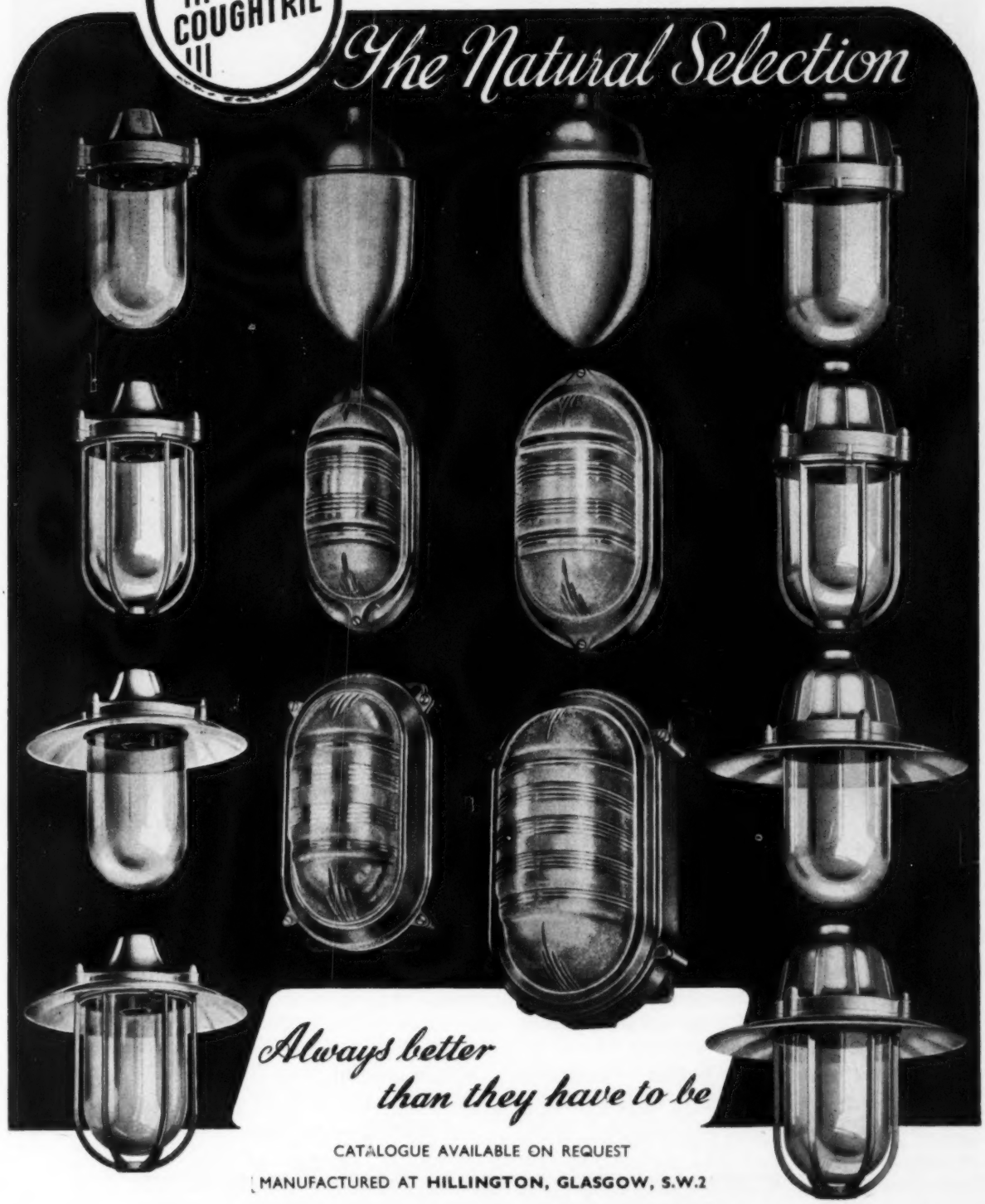

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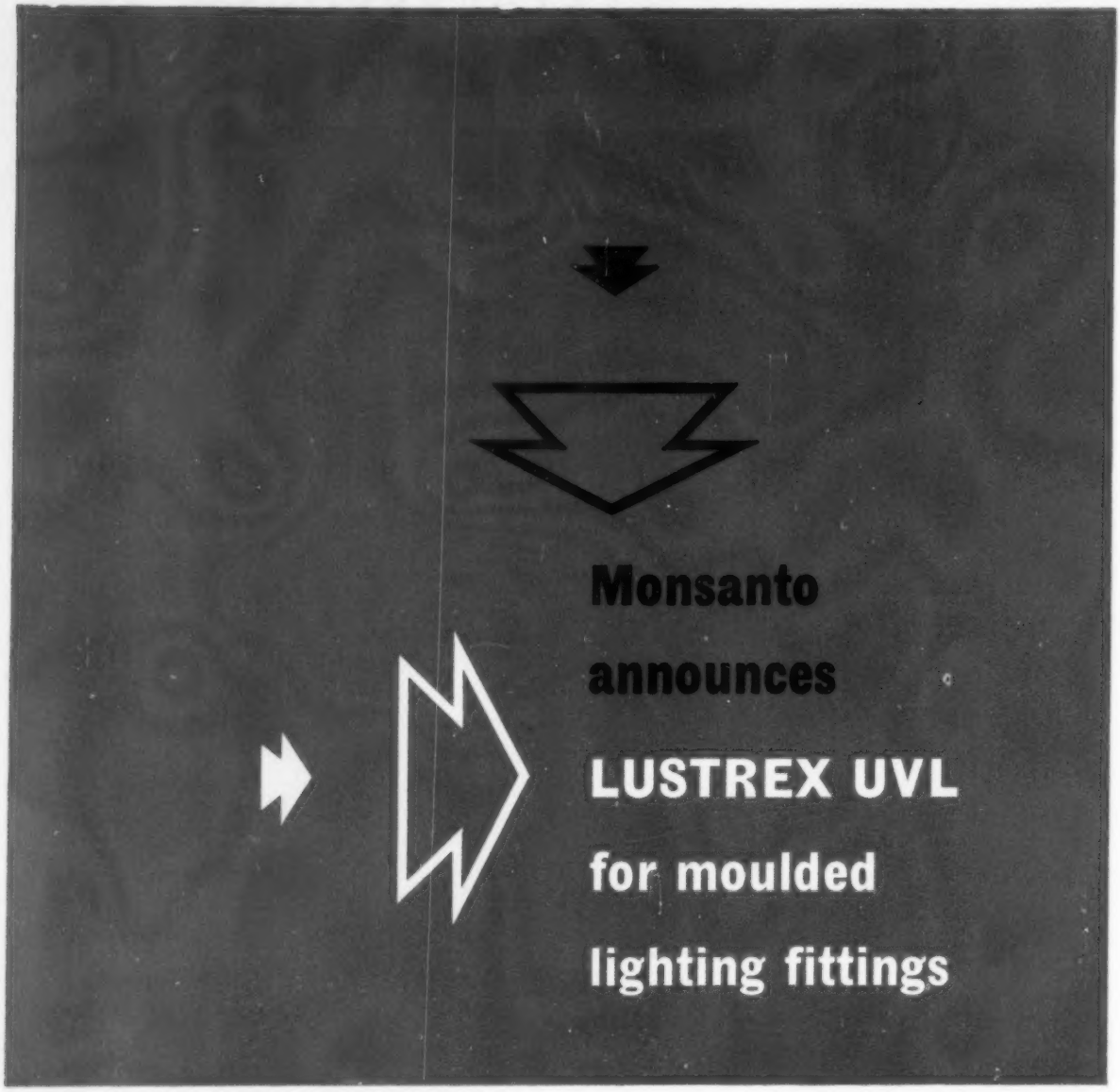

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Light and LIGHTING

Vol. 52. No. 3. March, 1959

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Education In Lighting

ADVANCES in knowledge are constantly being made in every field of human interest and lighting is a field which has had its fair share of advances in recent years. But the flow of knowledge still continues and, of the making of books and papers contributing to it there is no lack. All this must be assimilated by those who aim to make lighting engineering their career. We do not mean that every publication relating to aspects of lighting must be read entire by new students and established practitioners. That would be impossible as well as impossibly tedious. But, what is really new and useful—usually only a small fraction of what is published—adds something to the bulk of the knowledge teachers must impart and students must acquire. Lighting technology is becoming more complex and, notwithstanding the efforts of those who labour to save others labour, by compiling data tables and "simplifying" methods of design, the would-be lighting engineer has much to learn. But his technical knowledge may well be mis-applied unless he learns to "size-up" situations as well as possible. To find out what ought to be designed is the necessary prelude to good lighting design, and in this matter of "diagnosis" the student's education needs improvement.

Notes and News

THE Golden Jubilee Dinner of the IES was an impressive and very successful function. On February 9th fifty years ago 26 people forgathered at the Criterion Restaurant in London's Piccadilly where they dined informally and resolved to found what, later in the year, was named The Illuminating Engineering Society. In the same building three weeks ago about 450 members of the Society and their guests sat down to a commemorative dinner while, simultaneously, many members of the local Centres gathered at their own functions and had the London speeches relayed to them by landlines. The speeches were also transmitted to the South African Centre and we understand that, although some fading occurred, on the whole reception was good. The scene in the Criterion before the speeches commenced was described to the listening Centres by Mr. W. R. Stevens in his own inimitable manner and, by all accounts, with much satisfaction to his audience.

It was certainly a memorable occasion and a most appropriate beginning of the Golden Jubilee year celebrations. Unfortunately, the Lord Mayor, who was to have been among the imposing array of the Society's guests, was prevented by indisposition from being present, although the two City Sheriffs attended. Close to the President at the top table we were particularly pleased to see the Rt. Hon. the Earl of Mount Edgcumbe who is an original member of the Society. Dr. R. Lessing, another original member, was also present but the third surviving member of the founder group, Professor J. T. Macgregor-Morris—who was expected to attend—was, unfortunately, not well enough to do so. The guests also included representatives of the corresponding Societies in Australia, France and Germany. In proposing the toast to the IES, the Very Rev. A. C. Don, Dean of Westminster, contrasted the unworthy lighting of Westminster Abbey with the new scientifically designed lighting of Gloucester Cathedral. After the response by the President, Mr. C. C. Smith, who read a message of congratulation received from the Prime Minister, the Rt. Hon. Harold Macmillan, toasts were proposed to Science, Art and Industry. Appropriately, the first of these toasts was proposed by Dr. G. B. B. M. Sutherland who is Director of the National Physical Laboratory which has been so intimately involved in the development of lighting and has provided the Society with some of its most eminent personalities and presidents. Sir Charles Wheeler, President of the Royal Academy, spoke of the great importance of lighting to the visual arts and of the debt we all owe to it for its revelation of the beauties of colour. In proposing the toast to Industry, Mr. Leslie Gamage, Chairman and Managing Director of the GEC, claimed for Britain the leading lighting industry of the world. This leadership, he said, is due to the partnership of industry with science and art, and illuminating engineering as we know it today owes very much to research and development work which member firms of the lighting industry have financed. In a sparkling speech Dr. J. W. T. Walsh, President of the International Illumination Commission, proposed the toast to the Guests. Responding to this, Councillor David Cobbold, the Rt. Worshipful the Mayor of the City of Westminster, said that the first arc lighting was installed in his city's area as long ago as 1848. Today, the area within a quarter of a mile radius of St. James's has a load of 2,000 kW/sq. mile and provides the greatest concentration of lighting in the world. He was proud that the IES had its origin and has its headquarters in this area.

Another notable event occurred in February, a week before the IES Golden Jubilee Dinner. This was the Swan Memorial Lecture given in Newcastle-upon-Tyne by Dr. J. N. Aldington. Dr. Aldington's reputation as a public lecturer, particularly on light sources, stands so high that he was assured of a large audience and his audience certainly got what they expected—a fine lecture. All the more credit is due to Dr. Aldington in that during the preceding week he was a victim of the prevailing 'flu and was barely well enough to fulfil his important engagement in Newcastle. However, not only did he deliver the Swan Lecture but he also made a television appearance and, later in the same week, he gave a live broadcast on the BBC's Network 3 which was recorded and repeated in the Home Service on the morning of Saturday, February 7th.

Fitting the Job to the Worker

Lighting is one of the subjects under discussion at a Conference on fitting the job to the worker which is now sitting in Zurich under the auspices of the European Productivity Agency of the Organisation for European Economic Co-operation (OEEC). Two of the British delegates attending this conference are Dr. R. G. Hopkinson and Mr. H. C. Weston. We understand that Mr. Weston's first "international" paper on lighting in relation to industrial efficiency was delivered in 1927 at a conference in Italy and that he presented a further paper on this subject in Zurich—the venue of the present conference—30 years ago. He has been nominated to lead the British delegation to the CIE at the Brussels meetings in June.

One of the committee rooms in the new Paris headquarters of UNESCO (architects, Bernard Zehrfuss, Pier Luigi Nervi, and Marcel Breuer). Like many areas of the building, this room was furnished by a donation from a member nation—in this instance, Italy. The lighting fittings, partly recessed into a ceiling of olive wood, are of Murano glass.

The Samuel Whitbread

Leicester Square, London, w.1

Architects, T. P. Bennett & Son; interior design, Richard Lonsdale-Hands Associates. Electrical installation and lighting fittings, Troughton and Young Ltd.; other lighting fittings, Courtney, Pope (Electrical) Ltd., H. C. Hiscock Ltd., Osler and Faraday Ltd., and Tucker and Edgar Ltd.

WHITBREADS' "number one" public house occupies a site on the corner of Leicester Square, in the heart of London's "theatreland". Although in a dominant position, the site is an awkward shape—in plan, a segment of a circle. Thus, on each floor the rooms are of irregular shape, with one curved wall.

The principal areas for which Richard Lonsdale-Hands were responsible comprise a dive bar, below pavement level; a bar on the ground floor, with direct access from the street; a smaller, more intimate bar, to the rear of the ground floor bar; and a restaurant on the first floor. In the three bars distinct themes were adopted as the basis of the *décor*. Thus, in the dive bar, the theme is "traditional London", with a series of paintings by George Bass forming a modern equivalent to the traditional "Cries of London" and bar front panels in laminated plastic sheeting incorporating the coats of arms of the London boroughs.

The principal element of the dive bar is the serpentine shaped long bar at the hub of the segmental area. There are three bays of banquette seating along the curved outer wall with, between each bay, screens of acid-etched glass. At either end of the room extensive use is made of mirrored glass and there is a large map of central London on which the principal theatres and cinemas can be indicated by small lamps at the press of a button. Internal finishes comprise teak panelling; seating in lime-green and rust hide; and a patterned carpet in black and moss green.

The theme of the ground floor bar is the "signs of the zodiac". The gods and creatures of astronomy are featured in the laminated plastic panels of the bar front and the table tops and in the acid-etched panels of the bar fitment, while the walls are finished with several layers of glass treated in several ways to give a three-dimensional "star-studded" effect. The structural wall is painted midnight blue on which clusters of stars are painted, while the layers of glass, into which additional star shapes are cut, stand about 12 in. from the wall to create an illusion of movement when seen by a person passing through the bar.

The small bar at the rear—the "Gold Bar"—has a more opulant style of *décor*, carrying on the tradition long associated with "show business". There is a black carpet; banquette seating is covered with red velvet; walls have a gold finish; and a gilt chandelier of modern design is suspended from the ceiling.

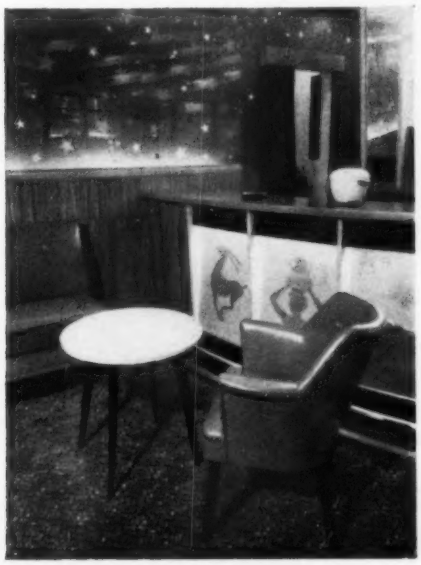
In the restaurant advantage has been taken of the unique outlook. There are unobstructed windows the entire length of the curved external wall and the area not immediately adjacent to the windows is at a slightly higher level than the remainder so that all diners have an uninterrupted view of the lively scene outside. (The long window forms a dominant feature of the curved façade.) The main element of the *décor* is the canopy of geometrically shaped panels of fibrous plaster, suspended from the dark-blue ceiling above. At either end of the room there are carved wall panels of "Perspex", edge lit to enhance the designs of the sculptor, Arthur Fleischmann. These designs represent the four seasons, depicting hops, barley, grapes and water—in the form of ice crystals—incorporating classical figures in low relief.

Of particular interest in connection with the design of the premises was the extensive use of a large scale model of the shell of the building which was made available to the design team at an early stage of their deliberations. The model was constructed so that each floor could be taken out, like a drawer, and the various wall, ceiling and furnishing treatments were accurately reproduced so that the total effect could be assessed. By using miniature lamps, the lighting effects, too, were simulated, and even the murals, clocks and other small items were included.

There are staircases at either end of the building, and both have been given interesting decorative treatment: slatted timber panelling on coloured plaster walls, with some areas finished with a new material based on a compound of natural crushed rock. Ceilings are blue—continuing the prevailing colour of the restaurant colour scheme—and specially designed tungsten fittings have been fixed directly to them.

Lighting

Lighting of the dive bar comprises cold-cathode tubing concealed by the canopy which follows the contour of



Top, the "Dive Bar," with indirect lighting from cold-cathode tubing concealed by the canopy and direct lighting from louvred downlights semi-recessed into the canopy. Above, ground floor bar, with indirect lighting from tungsten lamps concealed by the slats of the segmental ceiling and from the conical-shaped fittings in the alternate segments. Decorative glass panels above the bar fitting conceal fluorescent lamps. Left, close-up of counter front, with decorative panels lit by lamps concealed by the black pelmets. The "star-studded" wall comprises acid-etched and sand-blasted layers of glass lit by lamps concealed by the teak dado.

The Samuel Whitbread

Leicester Square, London, w.1

Architects, T. P. Bennett & Son; interior design, Richard Lonsdale-Hands Associates. Electrical installation and lighting fittings, Troughton and Young Ltd.; other lighting fittings, Courtney, Pope (Electrical) Ltd., H. C. Hiscock Ltd., Osler and Faraday Ltd., and Tucker and Edgar Ltd.

WHITBREADS' "number one" public house occupies a site on the corner of Leicester Square, in the heart of London's "theatreland". Although in a dominant position, the site is an awkward shape—in plan, a segment of a circle. Thus, on each floor the rooms are of irregular shape, with one curved wall.

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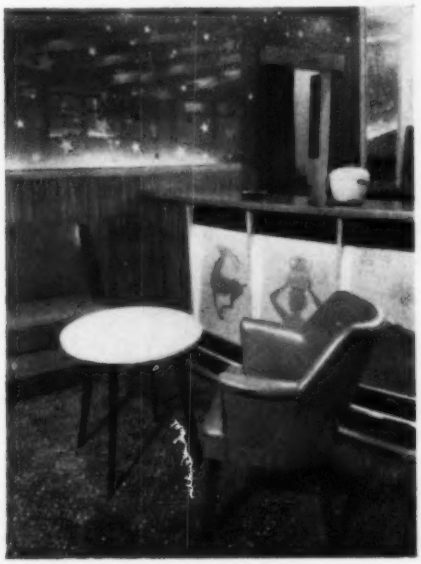

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the room and, over part of it, forms a low-ceilinged area. Partly recessed into this canopy are louvred downlights, with rims of perforated metal.

The ground floor bar is lit mainly by indirect light from conical shaped fittings of spun metal suspended from the plain segments of the segmental ceiling. Between these plain areas are slatted segments, with tungsten lamps concealed by alternate slats. Decorative glass panels above the back bar fitment are lit from behind by fluorescent lamps, while the " zodiac " panels of the bar front are lit by strip-lights concealed by the black plastic pelmets. The side walls above dado level comprise several layers of glass, set about 12 in. from the structural wall, into which various star shapes have been cut by acid etching, sand blasting and other techniques. Fluorescent lamps concealed by the dado shine on to these incisions in the glass to produce a sparkling effect.

The restaurant ceiling, described above, is lit by groups of tungsten lamps housed in fibrous-plaster troughs fixed to the columns, while the ceiling panels themselves conceal other tungsten lamps. On most tables there are small table lamps, with bases of spun aluminium and plastic shades.

Left, window tables of the first-floor restaurant showing the good view of the surrounding area. Table lamps have spun-metal bases and plastic shades. Fibrous-plaster troughs fixed to the columns house tungsten lamps that shine on to the geometrical ceiling panels. Below, another view of the restaurant, showing the edge-lit " Perspex " panels by Arthur Fleischmann and the view across Leicester Square.

Some Notes on Answers to the 1958 City and Guilds Examination Papers

By S. S. BEGGS,
M.A., A.M.I.E.E., F.I.E.S.*

AS a new branch of technology becomes established it becomes increasingly important for those practising in that branch to have a thorough understanding of the basic principles and their application to the many problems that are bound to arise in the course of their work. This has been recognised by The Illuminating Engineering Society, as shown by the recent raising of the standard of the qualification in illuminating engineering required for diploma membership from the intermediate grade to a final grade certificate of the City and Guilds of London Institute. It is thought, therefore, that many in the field of lighting, as well as past and future candidates for these examinations, will be interested in a review of the questions set in the 1958 papers, with comments on the type of answer which might be expected. The author acknowledges the kind permission of the C and G Institute to publish the question papers, and would emphasise that these notes represent his own personal interpretation of them and his own views of what constitutes a suitable answer. No doubt every examiner has his own idiosyncrasies, but—as in most educational matters—there is a fair accepted standard throughout the country.

Part I Intermediate Grade

The general standard of knowledge expected at this stage is a thorough understanding of the basic principles.

A certain amount of pure "science" is required, but this will have a bias towards that involved in lighting, e.g. radiation, optics and heat; also sufficient mathematical ability to comprehend what is happening in a calculation, as well as to derive the right answer, arithmetically or algebraically. Reasonable facility with the usual processes (such as logarithms) is essential; although calculus is not essential, ability with elementary manipulations—such as simple differentiation and integration—will be a great asset. Proper use of units and a knowledge of the methods of light measurement are an obvious necessity, as also an understanding of the properties of light sources and lighting materials. Only a general knowledge of lighting equipment and installations is expected, any detail being just sufficient to illustrate the application of the basic principle in a suitable form.

First Paper

1 *Compare and contrast the spectral distribution in the visible, ultra-violet and infra-red regions of*

(*i*) *a* 100-*watt incandescent tungsten lamp at normal voltage,*
(*ii*) *the same lamp at about* 80 *per cent voltage,*
(*iii*) *a* 250-*watt high pressure mercury-vapour lamp (not fluorescent.*

Exact values are not required, but the general proportions should be reasonable.

Hence account for the appearance of an object when successively lit by these three sources; the object in daylight is red, white and blue in equal stripes.

The radiation from a normal incandescent filament lamp (about 2,800°K) is mainly (about 90 per cent) in the infra-red (maximum at about 1 micron); the remainder is in the visible region, decreasing in amount with decreasing wavelength, with only a negligible amount in the near ultra-violet region. Under-running the lamp by 20 per cent in voltage lowers the filament temperature (by about 200°K); nearly all the radiation is in the infra-red region (maximum at about 1.5 microns), the remainder being in the longer wave-length visible with very

* Research Laboratories of The General Electric Co., Ltd., Wembley, England.
The final grade paper will be the subject of a subsequent article.

little violet and blue light, and the light output is about halved. These lamps have continuous spectra, but the 250-watt HPMV lamp has a line spectrum, with continuous background. Although the majority of the radiation is still in the far infra-red (from the heated envelope as well as the discharge itself), a greater proportion (about 15 per cent) is in the visible and a few per cent in the near ultra-violet region. Most of the visible light is emitted in the strong green (0.546 μ) and yellow (0.577/0.579 μ) lines; about an equal amount of energy is radiated in the violet (0.406 and 0.435 μ), and although, because of the lower luminosity, this represents only little light it can affect blue colours greatly. Approximately the same amount of energy (about 5 per cent) is radiated in the near ultra-violet region (mostly at 0.365 μ), but the far ultra-violet from the discharge is absorbed in the glass envelope.

In the coloured object the bands can reflect only colours contained both in the incident light and in the pigment. Therefore, the red will look bright under the normal incandescent lamp, but richer (although darker) with the under-run lamp, and will appear dark chocolate or black with the HPMV lamp. Contrariwise, the blue will look black with the under-run filament lamp, a dark blue with the normal lamp and a bright purple blue with the HPMV lamp. The white will (for psychological reasons) be judged as white under each lamp, but actually will be an off-white under the normal lamp, a light cream with the under-run lamp and a blueish white with the HPMV lamp.

2 *Write explanatory notes on three of the following:—*
(i) threshold of vision,
(ii) retinal fatigue,
(iii) dark adaptation,
(iv) Weber-Fechner law.

All these are dealt with fully in the standard text books. (See, for example, Walsh's "Textbook of Illuminating Engineering," chapter III.) Although these matters are in reality very complex (as a glance at Walsh's classic book on "Photometry" will make clear), the intermediate grade student is not expected to know more than the main characteristics and general levels involved; detailed knowledge relating to coloured light is more appropriate to Paper Two of the final grade examination, but even at this stage the student should know (for example) that the photochromatic interval exists. There is much confused thinking over the Weber-Fechner law, and a muddled account based on half-understood reading will not appeal to the examiner. The notes requested should be brief, but clear and comprehensive, and preferably should indicate the bearing of the phenomenon concerned on photometry and vision.

3 *Draw a circuit diagram for an "instant-start" fluorescent mercury discharge lamp, to operate from an a.c. supply at 240 volts, 50 c/s. Label all components, and explain how the lamp starts and how steady operation is maintained.*
Explain also
(i) how to reduce the supply current to a minimum without impairing the light output, and
(ii) why the power factor can never be unity.

There are a number of alternative circuits available for "instant-start" operation of a fluorescent mercury discharge lamp, the distinctive feature being the absence of the starting switch essential in the original circuit.

The circuit may be inductive or capacitive, it may include an "earth-strip" lamp or not; the candidate should illustrate and describe the operation of *one* suitable circuit with which he is familiar.

One example is shown in Fig. 1. When the main switch is

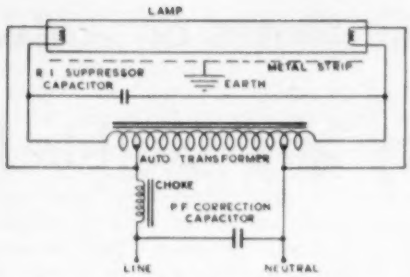


Fig 1. An "instant-start" circuit for a 5 ft. fluorescent lamp.

closed, the full mains voltage is applied across the primary of the auto-transformer and slightly higher than mains voltage across the lamp; the filament-heating windings supply current to heat the filaments rapidly, sufficiently to cause the discharge to strike at this voltage. The presence of the earthed strip or part of the fitting in close proximity to the discharge path facilitates the striking. When normal lamp current is flowing, the choke in series drops the voltage across the primary of the transformer (approximately equal to that across the lamp), so that the voltage and therefore the current from the filament heating windings is reduced, to a value just enough in conjunction with the heating due to the discharge itself to maintain the electrodes at the desired temperature for optimum emission.

(i) The lamp current normally is out of phase with the supply voltage. To reduce the current in the mains to a minimum, additional equipment is added to the circuit, taking current leading or lagging the supply voltage in opposite sense to that of the lamp circuit current, to balance (as far as possible) its out-of-phase component. If the lamp circuit is inductive (as in Fig. 1), a capacitor is connected across the main supply in parallel with the lamp circuit.

(ii) The power factor can never be unity because the wave form of the lamp circuit is not truly sinusoidal. Thus the integrated product of the current and voltage throughout the cycle is not equal to the product of the (root mean square) voltage and current, but somewhat less at best.

4 *Describe a bench photometer suitable for the intercomparison of small incandescent electric lamps with luminous intensities up to* 400 *candelas.*
Given that the voltage applied to each of two lamps under comparison is known within $\pm$ 0.5 *per cent, and that luminous intensity varies with the fourth power of the applied voltage, what is the uncertainty in the value obtained for the luminous intensity of a test lamp, that of the standard lamp being known within* $\pm$ 1 *per cent at rated voltage, and other possible errors being ignored?*

(i) A simple form of bench photometer is all that is required, and a description of such can be found in the textbooks.

(ii) If a quantity nominally x has a true value $x+dx$, the quantity nominally x^4 has in reality a value $(x+dx)^4$, which, if dx is small, to the first order is $x+4dx$. The inaccuracy of $\pm$ 0.5 per cent in the voltage on each lamp therefore gives rise to an inaccuracy of $\pm(4\times0.5)$, i.e. $\pm$ 2 per cent in the luminous intensity for a given measurement. If the voltage measurements on the lamps are independent, one might actually be under-run whilst the other is over-run. The maximum uncertainty due to the voltage variation is therefore $\pm$ 4 per cent, i.e. the true value for the test lamp may lie anywhere between $(1-0.04)$ and $(1+0.04)$ times the measured value for this lamp. Since the true value for the standard lamp may lie anywhere between 0.99 and 1.01 times the nominal

value, the true value for the test lamp lies between (0.96×0.99) and (1.04×1.01) times the calculated value, i.e. between $(1-0.04)$ $(1-0.01)$ and $(1+0.04)$ $(1+0.01)$, or (1 ± 0.05) of this value. The maximum uncertainty in the value obtained for the intensity of the test lamp is therefore $\pm$ 5 per cent.

Note: On a statistical basis, the values are not *equally* likely to lie anywhere between the limits quoted, but presumably are more likely to be near the nominal value. For the same probability of error (i.e. of lying between the stated limits) as applies to the other values, the limits for the intensity of the test lamp should be set at $\pm \sqrt{(0.02)^2+(0.02)^2+(0.01)^2}$, i.e. $\pm$ 3 per cent of the quoted figure. However, the examiner should not expect the intermediate grade student to discuss the statistical aspect of this problem.

5 *Comment briefly on the uses and purpose of a polar curve of luminous intensity.*

A light source has an axis of symmetry, and the luminous intensity at a direction θ from this axis is 800 *cos θ candelas for values of θ between zero and* 70°, *and nothing elsewhere. Determine the total light flux emitted by the source.*

(i) The purpose of a polar curve of light intensity distribution is to show *in a manner easily visualised* the variation of the light intensity around the light source in directions restricted to a particular surface (usually a plane, but may be a cone). If the distribution is symmetrical about an axis, the polar curve for axial planes gives a deceptive impression of the luminous flux, since this is not directly related to the size or area for different curves. The curve may be used to calculate the flux in the whole or part of an axially symmetrical distribution; or it may be used to calculate the illumination on a normal or inclined facet at one or more points lying in the surface for which the curve is drawn.

(ii) Since the polar curve has a precise mathematical form, the simplest solution is by integration. However, a solution by zone factors, Russell Angles or Rousseau Diagram would be accepted.

$$\text{Flux} = 2\pi \int_0^{70^\circ} 800.\cos\theta.\sin\theta.\,d\theta$$

$$= 2\pi.800.\left[\tfrac{1}{2}.\sin^2\theta\right]_0^{70^\circ}$$

$$= \pi.800.(0.9397)^2$$

$$= 2{,}220 \text{ lumens.}$$

6 *Sketch in fair proportion, labelling the details:—*

(i) the filaments of single-coil and coiled-coil incandescent lamps, and

(ii) the arrangements for supporting the filaments and connecting them to the terminal plates.

What advantage is gained by making the bulb diffusing? What methods are normally employed to effect this, and roughly how much light is lost by so doing?

The constructions of normal types of filament lamps are well described in most textbooks on lighting. (See for example Walsh's Textbook, Chapter VIII, or the excellent book "Electric Lamps" issued by the Lighting Service Bureau.) The sketches must be reasonably good.

The advantage of a diffusing bulb is principally the reduction of the luminance of the visible source, which minimises any tendency to glare in use. The greater the diffusion the larger the apparent source, which also has the effect of softening shadows.

The most usual method of providing diffusion is by acid etching the internal surface of the bulb. Sometimes the surface is coated with a thin layer of diffusing particles (e.g. china clay or finely divided silica); whilst for maximum diffusion an opal glass can be used for the bulb. The loss of light by good internal etching is insignificant (not more than 2 per cent); with silica coating the loss is about 5 per cent, whilst with an opal bulb it may be up to 10 per cent.

7 *Explain briefly what is meant, in relation to reflection, by the terms:—(i) specular, (ii) diffuse, and (iii) preferential.*

Two vertical plane specular reflectors A and B, 4 *inches square and* 4 *inches apart, face each other and are parallel, with their upper edges in the same horizontal plane. A ray of light from a point source of* 120 *candelas placed at the centre of the top edge of A is incident on B at* 15° *to the normal, and lies in a vertical plane perpendicular to A and B. Trace the path of the ray and its reflections on a diagram drawn to scale, and calculate the illumination thereby produced on the surface where the final reflection takes place. The reflection factor of A is* 85 *per cent and that of B is* 80 *per cent.*

(i) Specular reflection is that in which an image is formed, i.e. rays reflected at any element of the surface appear to come from an image of their source behind this element. In completely diffuse reflection the light is scattered equally in all directions, so that the luminance of the reflecting element is the same for all directions. Most surfaces have preferential reflection characteristics, in that an element reflects light neither only in the direction of specular reflection nor equally in all directions, but most strongly about one direction (the preferred direction) and decreasingly as the inclination to this preferred direction increases.

(ii) The path of the ray of light and its reflections is shown in Fig. 2.

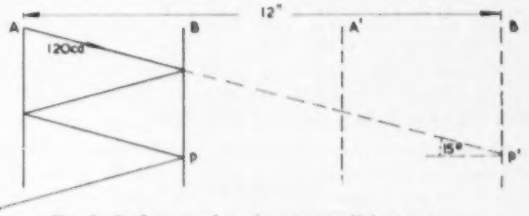


Fig. 2. Reflection of ray by two parallel mirrors.

The ray is reflected three times, once by A and twice by B, the last reflection occurring at the point P of Fig. 2. The illumination on the surface B at P is the same as that at the point P^1 of the surface B^1 spaced 1 ft. from A, if B were a non-diffusing filter of transmission 80 per cent and A^1 one of transmission 85 per cent. Hence,

$$\text{illumination of surface B at P} = \frac{120.(\cos 15^\circ)^2.(0.8).(0.85)}{1^2}$$

$$= 73.5 \text{ lm/sq. ft.}$$

8 *It is required to light a lock-up shop* 10 *ft. high and* 15 *ft. deep, with a* 20-*ft. frontage which includes a door at one side. The locality is a small suburban street and the shop is in the centre of a row of five. The trade is grocery.*

Making reasonable assumptions for the lay-out of the interior, give sketches and brief details of a suitable scheme, including the wiring to a 240-*volt,* 50-*c/s. supply.*

There are many alternative schemes which would be suitable, and the details are not important so long as the candidate makes clear the principles on which he bases his proposals. Since the locality is suburban a very high level of lighting is not called for, but, because there are closely adjacent shops, a sufficiently

high level and some distinctive arrangement to attract attention is desirable. Filaments lamps may be used, especially in the display area to obtain accent lighting and avoid a dull flat appearance; but tubular fluorescent lamps would be more suitable for the general lighting of the shop. Good colour is important, as many articles of food have a characteristic colour. It is preferable to arrange the lighting fittings in a localised pattern, i.e. in relation to the counters and sales area, rather than as a uniform general system; but, as the shop is not large, general lighting for the whole area with additional local lighting where necessary (e.g. at the pay desk) would be satisfactory.

The electrical wiring would follow a normal pattern (see, for example, Chapter XII of Walsh's Textbook).

9 *Describe some form of illumination photometer employing a photo-electric cell. Draw a circuit diagram and explain how the instrument works.*

It is found that such an instrument, with its "eye" looking out from a wall in a public assembly room, gives different indications depending on the number and attire of the company present, other factors being the same. Briefly discuss possible reasons for this.

(i) The candidate may describe any suitable instrument with which he is familiar. It is better for him, if possible, to choose one which he has himself used, rather than one of which he has only read a description, but it *must* be photo-electric. Complexity gains no extra marks.

The photo-voltaic cell is usually used, and the circuit is then basically merely a galvanometer in series, which may incorporate shunt resistances if more than one range is required.

(ii) Clearly the response of the cell depends on the amount of light which falls on it, some of which comes by reflection from the company in the room. If these are numerous they will obscure a large proportion of the furnishings of the room, and the amount of reflected light reaching the cell then depends upon the light or dark shade of their attire.

Second Paper

1 *If a surface is illuminated by a line source parallel to the surface, the illumination on it is given by*

$$E=\frac{I}{2D}\left[\tan^{-1}\frac{l}{D}+\frac{lD}{l^2+D^2}\right]$$

where I *is the intensity per unit length,* l *is the length of source, and* D *the distance between source and surface.*

A line source, 5 ft. long, has a maximum intensity of 300 candelas. Calculate the illumination according to the formula for points between 1 and 10 ft. distance, showing the results graphically. On the same graph, plot the illumination which would be produced by a point source of the same intensity.

For the given source, $I=300/5=60$ cd/ft. and $l=5$ ft.; thus the illumination at distance D is

$$E=\frac{30}{D}\left[\tan^{-1}\frac{5}{D}+\frac{5D}{25+D^2}\right]$$

(N.B. The angle $\tan^{-1}\frac{5}{D}$ must be expressed in radians, not degrees.)

The illumination at only three or four points need be calculated, e.g. for D = 1, 2, 5 and 10 ft. A graph relating illumination and distance is shown as curve A in Fig. 3.

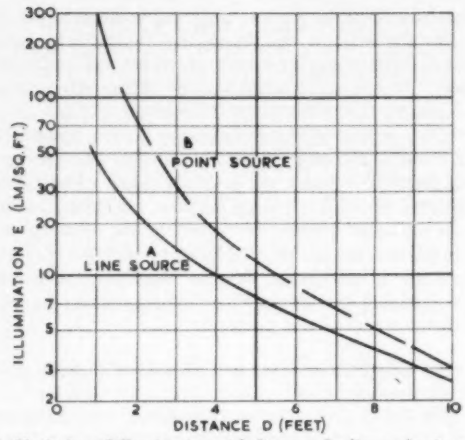


Fig. 3. Variation of illumination with distance for line and point sources.

The formula relating illumination to distance for a point source of the same intensity is

$$E=300/D^2.$$

The corresponding graph is shown as curve B in Fig. 3.

[*Note:* The formula quoted in the question for a line source is that for a surface facing the source and *opposite one end;* the difference between the values for the line and point sources is therefore accentuated, and is greater than indicated in Fig. 46 of Walsh's Textbook.]

2 *The 140-watt sodium discharge lamp is available in two forms, namely, with an integral and with a separate outer jacket. Describe one of these lamps and discuss its advantages and disadvantages compared with the other.*

The candidate should describe the form of lamp with which he is the more familiar. There is no *fundamental* difference, the most significant one being that in the integral jacket form, the discharge tube is permanently sealed into a single-walled jacket—in exactly the same way as for the HPMV lamp—instead of having a detachable double-walled jacket, as shown for example in Walsh's Textbook, Chapter VIII. The limbs of the discharge U-tube (of somewhat wider bore) are sleeved with glass tubing (for conservation of heat), and the electrical characteristics are slightly different.

The integral-jacket form of the 140-watt lamp has several advantages. It has a higher luminous efficiency (by about 10 per cent), and a lower striking voltage so that striking of the arc is more reliable in damp weather; it is more robust and neater in appearance, with only one light-transmitting surface exposed to the air and subject to accumulation of dirt. Its only practical disadvantage is that it is more expensive than the inner tube alone of the separate jacket form, and the relative economics of its use depends on how often the separate outer jacket has to be renewed with the latter form. If the outer jacket can be made to outlast three inner tubes without serious deterioration, the separate-jacket form will be less costly at present-day prices.

3 *What are Russell Angles? Derive a set of* 10 *angles, covering* 180°, *and use them to determine the luminous flux defined by the following light distribution:—*

Angle.	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
Intensity.	48	70	100	125	145	170	180	185	185	180
Angle.	100°	110°	120°	130°	140°	150°	160°	170°	180°	
Intensity.	176	173	170	165	140	100	35	20	0	

Angle 0° *corresponds to the downward vertical, and the distribution is symmetrical about the vertical axis.*

This is a pure "textbook" question.

(i) Russell Angles are angles corresponding to the centres of equal zones of solid angle symmetrical about an axis, usually covering the whole sphere of space about a source.

(ii) The 10 Russell Angles required may be derived in any of several ways—even via a Rousseau Diagram. However, the best way is as follows. (*Note:* Since the question says "derive," it is not sufficient to quote them, even if you can.)

The ten zones are each of solid angle $(4\pi/10)$ steradians. The solid angles of the spherical caps from the axis to the limits of successive zones are therefore $(4\pi/10)$, $2(4\pi/10)$, $3(4\pi/10)$ ... $9(4\pi/10)$ and 4π; and to the centres of successive zones are $\frac{1}{2}(4\pi/10)$, $(3/2)(4\pi/10)$, $(5/2)(4\pi/10)$, ... $(19/2)(4\pi/10)$ steradians. Since the solid angle of a zone extending from the axis to an angle θ is $2\pi(1-\cos\theta)$, the Russell Angles θ_1, θ_2, θ_3, ... θ_{10} are given by: $2\pi(1-\cos\theta_N)=\left(\frac{2N-1}{2}\right)(4\pi/10)$, where N successively has values 1, 2, 3, ... 9, 10.

This equation may be written $\cos\theta_N=(11-2N)/10$. The desired Russell Angles are therefore those of which the cosines equal (9/10), (7/10), (5/10), ... (1/10), (−1/10), (−3/10) ... (−9/10), viz. 25.8°, 45.6°, 60.0°, 72.5°, 84.3° and their supplements.

(iii) The intensities at these angles may be obtained from the tabulated values by drawing a graph (on either polar or Cartesian co-ordinate paper). To sufficient accuracy the intensities are:—115, 160, 180, 185, 184, 177, 174, 170, 158, and 75, of which the sum is 1,578. If the intensities are given in candelas (which the question omits to say), the total luminous flux is $(4\pi/10)$ (1,578), i.e. 1,980 lumens.

4 *Describe, with carefully drawn diagram, the construction and operation of a superheated multiple-mantled low-pressure gas burner.*

The candidate may describe *any* suitable burner which complies with the description given; a number of alternatives are indicated in Walsh's Textbook, Chapter VII. The diagram is an important part of the answer, and must be well done.

5 *Explain the "coefficient of utilisation" method of calculating illumination in an interior. In what circumstances does this method break down?*

Note down, with brief explanation, your estimate of the coefficient of utilisation for:—

(a) standard dispersive reflectors,

(b) general diffusing fittings,

(c) indirect pendant fittings

for a room 30 ft. wide by 40 ft. by 15 ft. high, assuming the ceiling to have a reflection factor of 70 per cent and the walls 50 per cent, the fittings being suspended three feet below the ceiling.

(i) The explanation of this method of calculating illumination in an interior is given fully in the textbooks. The points to emphasise are that it gives only an average value of illumination, and assumes moderate uniformity of the walls and ceilings, with not too low reflection factors.

The method tends to break down in a very small installation of direct or semi-direct lighting fittings, or of general diffusing fittings if the walls are very dark; for the effect of the walls then is significantly greater than assumed for the general case, since a relatively high proportion of the light flux falls on them. It may also give erroneous results if the lighting fittings have a markedly asymmetric light distribution, since the amount of light falling on the walls may depend on the orientation of the fittings. In any case the actual illumination obtained will bear no relationship to the calculated value, if the room is filled with objects of reflectivity quite different from that of the walls.

(ii) The room is of moderate size, so the walls may have significant effect. The reflection factors of the walls and ceiling are fairly high, and the mounting height is reasonable. All the three types of fittings listed should have a good light output ratio (about 70 per cent).

(a) Dispersive reflectors give markedly direct lighting, with relatively little light falling on the walls and ceiling. The coefficient of utilisation is likely to be about 0.5.

(b) The general diffusing fittings direct a large part of the light on to the walls and ceiling, where some is absorbed and the remainder diffusely reflected, so that only a small proportion of this light reaches the working plane. The coefficient of utilisation should be about 0.4.

(c) With indirect pendant fittings no light reaches the working plane directly, and the majority of that received comes after reflection at the ceiling, where it has been diffusely scattered. The coefficient of utilisation will therefore be about 0.3.

6 *Explain the difference between "disability glare" and "discomfort glare."*

These forms of glare sometimes occur in interior lighting. Give an example of each type, showing how it can be reduced.

(i) Disability glare is the reduction or prevention of the ability to see objects due to the presence of a bright light or area in the field of view; it is not necessarily accompanied by discomfort. Discomfort glare is the effect of too high contrasts in the field of view, which (either at the time or over a period) produce a feeling of discomfort (and possibly headache), without necessarily directly affecting the ability to see.

(ii) The student may describe any suitable examples of these two forms of glare, together with a possible remedy.

One example of disability glare is the reflection of a room light in the face of a television tube, which prevents an area of the programme picture from being seen, but probably without engendering discomfort to the eye. The simplest solution is to arrange the position of lamp, screen and viewer so that no specular reflection of the lamp is visible to the observer.

On the other hand, discomfort glare will result if the level of lighting in the room when watching television is too low relative to the brightness of the screen itself; the effect may be immediate discomfort or a headache after the programme is finished, but vision of the picture is not disturbed. The remedy is to have a moderate level of illumination of the background to the screen and set, e.g. by a small lamp placed behind it.

7 *Discuss the purpose of Group B street lighting, and describe a typical installation. Refer to the accepted Code of Practice in your answer.*

The essential object of Group B street lighting is to provide visibility, safety and amenity to pedestrians and slow local traffic and to occupants of adjacent property; the area of prime importance is not merely the carriageway, but the whole of the space between the building lines, and the frontages of the buildings themselves must not be neglected.

The candidate may describe any suitable installation, indicating the recommendations of the BS Code of Practice (CP1004: Part 2: 1956) on the subject. The main items for consideration are the amount of light and type of light distribution provided: the mounting height, spacing and lay-out of the lanterns: and the importance of amenity in the district. (These are all discussed in the relevant Code.)

8 *A circular convex lens of 3-inch diameter and 6-inch focal length is fully flashed by a disc source $\frac{1}{2}$ inch in diameter placed normal to the optical axis of the system at the focus.*

Calculate approximately the intensity distribution from the lens, assuming the source is a perfect diffuser of brightness 1,000 *stilb.*

Since the source is at the focus of the lens, rays from the source centre emerge parallel to the axis; and the pencil of rays emerging from any point of the lens form a cone, centred about this parallel ray and of apex angle equal to that which the source subtends at this point.

The source subtends an angle at the centre of the lens equal to 2 $\tan^{-1}$ (1/24), i.e. 4.8°; the angle subtended at any other point of the lens is very little less (actually a minimum of 4.5° at the edge of the lens).

Thus the lens appears fully flashed from any direction within $\frac{1}{2}(4.5)^\circ$ of the axis, but appears completely dark in any direction more than $\frac{1}{2}(4.8)^\circ$ from the axis.

The area of the lens is $\pi.(1.5)^2$ sq. in., or $\pi(3.81)^2$ sq. cms. Since 1 stilb equals 1 cd. per sq. cm., if there were no losses in transmission the maximum intensity would be $\pi.(3.81)^2.1{,}000$ cd., i.e. 44,510 cd. Allowing about 10 per cent for surface reflection and transmission losses, the intensity from the lens has an approximately constant value of 40,000 cd. within 2 1/4° of the axis, falling rapidly to zero at and beyond about $2\frac{1}{2}^\circ$ to the axis.

9 *Explain and compare Additive and Subtractive Colour Mixture.*

The accompanying table gives the energy in arbitrary units at different wavelengths of light of two different colours A and B. Plot curves, showing the relation between energy and wavelength for each light, and for the resultant when the two are mixed. What colour is represented by each of these curves?

Wavelength. (μ)	0.4	0.45	0.5	0.55	0.6	0.65	0.7
Energy Light A.	0.1	0.1	0.1	0.15	0.5	0.8	0.85
Energy Light B.	0.05	0.2	0.6	0.4	0.15	0.1	0.1

The units used are the same for light A and light B.

(i) Additive colour mixing is the production of a colour by the addition (either at the object or in the eye) of all the radiation of two or more separate coloured lights. An example is the type of colour-film in which the colour is obtained by a single layer of minute grains dyed red, green or blue. Any other colour is derived by the eye adding the radiation from the many grains in an area too small for resolution.

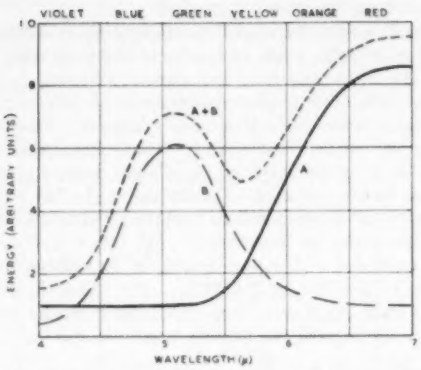


Fig. 4 Spectral energy distributions of lights A and B.

Subtractive colour mixing is the production of a colour by the absorption of some of the radiation from a white or coloured light, in transmission through or reflection from one or more coloured media, so that the final colour is that of the original radiation *less* the absorbed radiation. An example is the type of colour film in which the colour is obtained by the super-position of three thin films dyed cyan, magenta and yellow, which broadly absorb red, green and blue respectively from white light. Any colour in the transparency is that of the radiation from the viewing source transmitted by appropriate densities of all three filters, i.e. less the excess amounts of red, green and blue in the viewing light.

(ii) The spectral energy distributions of the lights A and B separately and together are shown in Fig. 4. Light A consists mainly of long wavelength radiation, red and orange with some yellow; bearing in mind the relative luminous efficiency of radiation, it will therefore appear orange.

Light B contains mainly blue and green, with some yellow radiation; it will appear green in colour.

The mixture of lights A and B has a large amount of radiation of the longer wavelengths, and a fair amount in the blue-green region, with a slight dip in the yellow and a deficiency in the short visible wavelengths (violet). It will therefore not appear strongly coloured, but a greenish yellow light—rather like that of a gas mantle.

The Physical Society Exhibition

A report on the exhibits at the forty-third exhibition of the Physical Society held in London in January.

This year the Physical Society reverted to its earlier practice of holding the exhibition of scientific instruments and apparatus in January instead of in the Spring. The number of exhibitors does not alter greatly from year to year but the crowds of visitors seem to become larger on each occasion and both Halls of the Royal Horticultural Society were thronged throughout the four days for which the exhibition was open.

Photometers

A number of instruments used for making photometric measurements of various kinds were shown by different exhibitors. Megatron Ltd., in addition to cosine-corrected illumination photometers, showed their "integrating light meter" used for measuring the total light flux reaching a point, irrespective of the direction of incidence. Another instrument designed for making measurements of this kind was the "diffuse light integrator" exhibited by the Chemical Defence Experimental Establishment (Ministry of Supply). This instrument consists of a solid 45° cone of "Perspex" seated on the top of a polished "Perspex" cylinder, 1½ in. in diameter and 1 in. high. This cylinder has a 45° conical cavity and is mounted on a photo-voltaic cell in the centre of a 12 in. blackened metal disc. All the conical surfaces have a matt finish and the solid cone is painted black from the apex downward for a sufficient distance to ensure that over the forward hemisphere the response of the instrument is practically independent of the direction of incidence of the light. The extent of the painted surface is arrived at empirically and a surprisingly good performance is claimed for the device, which has been used to integrate the diffuse and direct light from a lamp in fog and smoke.

Evans Electroselenium Ltd. showed their "EEL" street lighting photometer in which the cosine-correction system used by Pleijel and Longmore (*J. Sci. Insts.*, 1952) is em-

ployed. The instrument has four ranges with maxima respectively at 0.1, 1, 5 and 25 lm/ft² and correction factors are provided for illumination by mercury, sodium and fluorescent lamps and daylight.

Perhaps the most astonishing photometric instrument shown was a Lummer-Brodhun head stated to be "intended mainly for instructional purposes." The construction followed that of the conventioned contrast head (except that the usually rhomboidal patches were rectangular) but although contrast plates were shown in the diagram exhibited with the instrument, they seemed to be absent from the head as demonstrated. That this was not an oversight seemed clear from the catalogue description which read "the correct light balance is obtained when the two half fields with their associated contrast patterns present a field of uniform intensity." However, this specimen was described as a prototype and it is to be hoped that in the final model the "contrast pattern" will not belie its name.

Light Sources

Passing from photometers to lamps, a number of interesting exhibits may be noted. The Research Laboratories of the GEC had two, concerned respectively with filament and with fluorescent lamps. The impurity level in the argon-nitrogen filling of a filament lamp must be kept below a few parts per million for the best lamp performance. Such levels cannot be assessed easily and in common practice the quality of gas-filling during manufacture is checked by noting the colour and form of a high frequency discharge in the lamp. A study of the spectra of the different types of discharge under various conditions of excitation has shown the presence of CH and CN molecules, the concentrations of which change during the life of the lamp. A green afterglow is seen in some lamps, due to the auroral green line of atomic oxygen, in association with a continuum. Its maximum intensity occurs at an oxygen concentration of less than 5 parts per million. The other exhibit referred to was of the current and voltage waveforms in a tubular fluorescent lamp when inductively and resistively ballasted.

Thorn Electrical Industries Ltd. gave a brief catalogue description of their VHO (Very High Output) fluorescent lamp with a loading of 30 watts per foot and a luminance of the order of 19 cd/in². This was stated to be in "limited production." Both this firm and the Research Laboratory of the BTH Company had exhibits of electroluminescent devices for information display. The warning signs and notices forming the Thorn exhibit were operated on a 400 cycle supply, such as that used on aircraft, and had a luminance of some 30 ft-L.

Another Thorn exhibit was of an electroluminescent X-ray image amplifier, giving a 30 to 50 times luminance gain over a conventional fluorescent screen. The device was, in essence, a composite "sandwich" in which the two layers of "meat" consisted respectively of a photo-conductor and an electroluminescent phosphor. X- or gamma-radiation falling on the photo-conductor caused it to conduct locally and thereby increase the voltage across the electroluminescent layer, with the result that light was emitted over those parts of the field corresponding to the areas irradiated.

The BTH exhibit included complex panels with shaped electrodes representing electrical, mechanical, hydraulic or other elements; such panels are now being used to depict the mode of operation of complicated production processes.

Two applications of xenon arcs were shown by Siemens Edison Swan Ltd. The first was a simple colour-matching unit containing two 100-watt xenon lamps side by side; the other was a shutterless cinema projector. The response of the xenon lamp to arc voltage is so rapid that it is possible to move the film forward while the arc is extinguished between positive and negative half-cycles of a.c. voltage. In the demonstration, with 8 mm. colour film and a throw of a few feet, the flicker did not seem to be any greater than that in the picture given by a conventional projector.

Densitometers

As at previous exhibitions, there were a number of exhibits of densitometers, many of them automatic in operation. The Baldwin Instrument Company Ltd. showed various types which they have in regular production, but this year they included also a "macrodensitometer" designed specially for the National Coal Board for measuring the densities of small areas. Their "film badge photometer" was an instrument intended for use with a transmission density measuring unit to give accurate readings of the density of radiograph film badges.

The Locarte Company showed an automatic recording densitometer, based on a design by D. J. R. Laurence. This employed a nine-stage multiplier photocell the output of which, when further amplified, actuated a 1 ma. pen recorder. The instrument was described as "for scanning electrophoresis patterns. Joyce, Loebl and Co. Ltd. showed a prototype model (Mark IV) of their double beam automatic recording photometer, incorporating a number of new features as compared with the earlier model. They also exhibited their automatic reflectance densitometer and a 4-beam differential colour-measuring instrument.

Photocells and Various Devices

The applications of multiplier photocells continues to increase and it was therefore interesting to notice two eleven-stage cells shown by Rank Cintel Ltd. One of these was described as red sensitive and the other as blue sensitive. For both cells the overall sensitivity stated was 10 amps per lumen, with a maximum output of 100 microamps. The overall operating voltage was 1,250 volts. Twentieth Century Electronics Ltd. had on display a collection of their cells which were exhibited last year.

The Tintometer Ltd. besides exhibiting a typical range of instruments seen on previous occasions, showed a prism attachment for bringing the two apertures in the Lovibond comparator into a single field with a fine central dividing line. The attachment can be clipped quite simply to the front of any Lovibond comparator.

Finally, mention should be made of the headlight alignment apparatus shown by the Road Research Laboratory (DSIR). This consisted of two small screens mounted on an upright pillar supported on a wide three-legged base to minimise errors due to irregularities of the floor. One screen was used to measure the vertical aim of a headlight beam and the other its horizontal alignment. Projecting blocks at the ends of the screens, when introduced into the beam, cast shadows on the screens and the aim or alignment of the beam could then be determined by noting the directions of these shadows in relation to reference marks. A subsidiary instrument, called a "headlamp deterioration meter," gave the total luminous flux in the beam projected by the reflector of a headlight and so could be used to measure the state of deterioration of a headlight or, indeed, of any auxiliary lamp.

The Colour Group of the Society was not exhibiting this year. There was, however, an interesting display of Swedish instruments, organised by the Royal Swedish Academy of Engineering Sciences.

LIGHTING THE RETAIL STORE.....3

Newly decorated Jaeger shops: architect, Dennis Lennon, M.C., A.R.I.B.A.

THE first Jaeger shop was opened in February 1884 by L. R. S. Tomalin (grandfather of the present chairman) in the City. This shop sold all-wool clothing (mostly underwear), camelhair blankets and woollen sheets. This policy resulted from Dr. Jaeger's theory that, being animals, we should wear animal clothing and that wool, therefore, was the most health-giving of all fibres to wear next to the skin. This idea received a great deal of publicity at the time and George Bernard Shaw created a sensation by walking about London in a knitted brown Jaeger suit.

Nowadays, although Jaeger shops sell garments in other materials, the firm is still principally concerned with woollen garments. In the retail shops, of which there are now 41, there are coats, knitwear, dresses, suits, hats, underwear, etc., while the wholesale company sells to agents all over the country such items as dressing gowns, underwear, knitwear, knitting wool and socks —mostly menswear.

In the Jaeger shops—say their publicity department—everything possible is done to make buying and selling " comfortable and easy ". Lighting schemes, display counters and hanging rails are all designed with this end in mind, and in all the shops there is a feeling of space and light. The firm's newest branches are in Guildford and Torquay, while their Regent Street (London), Bristol, Liverpool and Cheltenham branches have all recently been renovated under the direction of Dennis Lennon, MC, ARIBA.

In Mr. Lennon's own words, the basic objectives of his designs are " to sell ", " to attract custom ", and " to maintain a contented staff ". He aims at an atmosphere that is friendly and efficient, using generally subdued lighting effects with direct lighting, whenever possible, for the goods themselves. In most of his schemes these aims are achieved by a combination of tungsten and fluorescent general lighting (the fluorescent lamps being used indirectly), supplemented by direct lighting from tungsten spotlights.

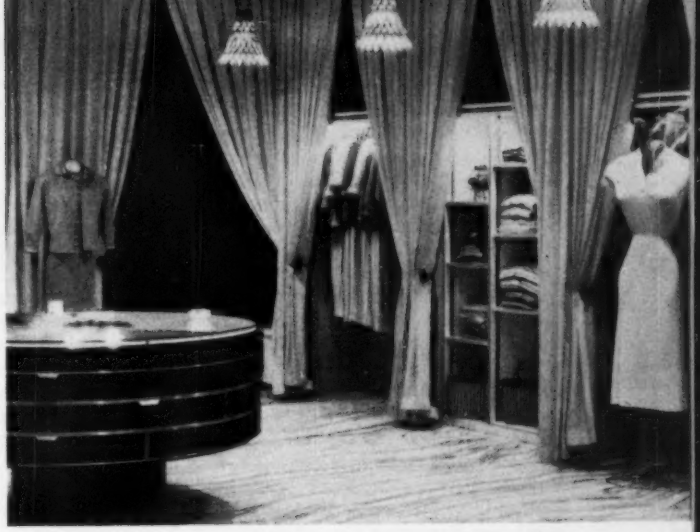
On the five floors of Jaeger's Regent Street store—all refurbished within the last few years—one can see numerous examples of the practical application of these principles. On the fourth floor (lingerie and children's department) general lighting is from fluorescent lamps concealed by pelmets along the top edges of the storage fittings. In slits in the ceiling adjustable internally-silvered spotlights are recessed, while fixed to some of the storage units are standards with pleated silk shades.

Opposite, third floor of Regent Street branch, with random arrangement of louvred spotlights in ceiling; indirect light from lamps concealed in the revolving storage units and from fluorescent lamps under the glass shelves in the mirrored recesses. Right, " boutique " in same branch, with decorative pendants with silvered finish.

On the third floor (coats and jackets) there is indirect light from fluorescent lamps concealed by the edge of the suspended ceiling. Into this ceiling louvred spotlights are recessed, while extra light comes from rings of 12 tungsten lamps concealed in revolving display units and shining on to the ceiling. Decorative pendants in mirrored wall recesses have shades comprising " petals " of silvered metal, and more fluorescent lamps are concealed by low-level glass shelves in other wall-recesses. At the rear of this floor is a " boutique " for the sale of hats, costume jewellery and other " accessories ", lit by the " petal " fittings described above, by louvred spotlights in the soffits of the window recesses and by spilt light from fluorescent lamps in the hanging spaces.

The second floor is devoted to suits and dresses and is lit by a large decorative tungsten fitting suspended from the ceiling ; by fluorescent lamps concealed by a pelmet around the periphery of the sales floor ; and by a ring of low-wattage lamps partly recessed into the ceiling. The sportswear department on the first floor has a decorative ceiling of octagonal shaped white panels, from which are suspended decorated opal-glass shades. " Sparkle " is provided by small naked lamps standing in a row along the top of the wall storage fittings.

The ground floor of the store, with large windows on two sides little obstructed by the sophisticated window displays, receives a great deal of natural light. Window lighting is from spotlights in the high soffits and from eyeball spotlights on the floor. In the sales area, spilt light from these fittings is supplemented by pendant fittings with shades of silk " petals " and by a circular unit nearly 5 ft. in diameter fixed above a large display fitting. This unit houses a ring of 12 tungsten lamps concealed by a shade of raffia. Powerful projector spotlights are directed on to the displays of clothing, providing a dramatic spectacle for passers-by after shopping hours.



Above, part of lingerie department in Regent Street branch, with fluorescent lamps concealed by pelmets of storage units and tungsten lamps in pleated silk shades. Left, Bristol branch, with perforated metal wall-lights; internally lit storage units and, at rear, random group of opal-glass pendants.

Lighting Abstracts

OPTICS AND PHOTOMETRY

628.98

647. Brightness survey of two rooms using a photographic technique.

M. N. ZEOLLA, *Illum. Engng.*, **53**, 537-542 (*Oct.*, 1958).

To eliminate the difficulty of making indoor luminance surveys under variable daylight conditions, a multi-plate colour camera has been adapted to take three simultaneous exposures of the room interior. By using filters of different density in each of the optical systems, the three negatives can be made to cover different parts of the total luminance range. The negatives are developed to extreme contrast to produce equal-luminance contours, spot measurements with a photoelectric photometer being used for luminance calibration purposes. Various techniques for reporting the results are illustrated. P. P.

535.241

648. Use of lenses for correction of cosine error in photovoltaic cells.

H. G. DLUGOS, *Lichttechnik*, **10**, 565-567 (*Nov.*, 1958). *In German.*

The cosine error of a given photovoltaic cell may be corrected by placing over the cell a plano-convex lens of curvature suited to the error curve of that particular cell, but for large angles of incidence there is gross over-correction. This may be overcome by fitting round the edge of the lens an opaque ring of suitable form and the author describes a system for which the error is found not to exceed 3 per cent. at any angle up to 85° from the normal. J. W. T. W.

649. Measurements on retro-reflecting materials. 535.24

J. KROCHMANN, *Lichttechnik*, **10**, 515-518 (*Oct.*, 1958). *In German.*

The luminance factor of a retro-reflecting material depends on the angle of incidence of the light and on the angle of view. When these are as nearly the same as the dimensions of the measuring apparatus will allow, they are frequently taken as equal. The author shows how the error so caused increases rapidly with angle of incidence and how it depends on the dimensions of the light source, the sample measured and the photometer (usually photoelectric). In the German standard DIN 67/520 retro-reflecting materials are divided into three classes according to the angle at which the luminance factor falls to half its value at normal incidence. J. W. T. W.

650. Modern methods of projection in the cinema. 778.55

H. ULFFERS, *Lichttechnik*, **10**, 409-416 (*Aug.*, 1958). *In German.*

After a detailed description of the various systems used for conveying a stereoscopic impression to a cinema audience, the author considers the optical problems involved. In some wide-screen systems the loss of light is considerable, and a beam of greater total lumens is needed to give the same screen luminance. The heating of the film at the gate causes curling and this has to be allowed for in designing the projector. A diagram shows the flux required on the different systems (a) for an ordinary white screen, and (b) for a metallised screen with a luminance factor of 1.8. J. W. T. W.

LAMPS AND FITTINGS

651. Efficiency of domed acrylic skylights. 628.92

E. LINFORTH, *Illum. Engng.*, **53**, 544-546 (*Oct.* 1958).

The photometric characteristics of square domed skylights made of three grades of white translucent acrylic sheet have been determined when used alone and in conjunction with ceiling wells with and without diffusing bottom panels. Measurements were obtained for both overcast sky and clear sky with direct sunlight conditions. The light transmission efficiencies of the skylights have been tabulated. Corresponding total solar energy data are not given, but, for the grades of acrylic sheet considered, these have been measured and found to be the same as for visible radiation alone. P. P.

621.327.43

652. Striking potentials of long, low-pressure, rare-gas electric discharges with and without mercury.

R. H. MCFARLAND and R. BAKIS, *Illum. Engng.*, **53**, 557-561 (*Oct.*, 1958).

Earlier works (*Illum. Engng.*, 1957) reported the striking potentials in long, low-pressure discharge tubes using an argon gas filling. This recent work extends the findings to neon, krypton, xenon and argon, with and without mercury vapour present. The data are given in the form of graphs showing the variations with gas filling pressure of the lamp volts necessary for various phases of starting and operation. P. P.

621.329

653. Present position of control and dimming of light, particularly from fluorescent lamps with reference to the new installations at the Royal Opera House at Versailles.

G. LEBLANC and C. DRUMONT, *Bull. Soc. Franc. Elect.* (7th Series), **8**, 537-544 (*Sept.*, 1958). *In French.*

Describes the installation of control equipment at Versailles. The autotransformer dimming equipment installed in 1953 for the control of the Son et Lumiere spectacle is also used for the control of a part of the stage lighting of the Opera House. This equipment provides 100 controlled circuits and is used for incandescent lamps. This is insufficient, and a further control board operating with thyratrons provides a further 100 circuits. Fluorescent lamps, used particularly for blue and green circuits for cyclorama lighting, are controlled from the electronic dimmer. The switching and operating controls for both boards are, however, identical in operation though their function is different. The dimmer controls are miniature levers which can be coupled to masters and a grand master in the conventional way, though in fact they operate the potentiometer of the remote control systems. Thus operators have not to learn new techniques. A "cleromon" control is however, provided at the master control point and a similar master control can be provided in the prompter's box and at a position in the auditorium used in rehearsal. J. M. W.

LIGHTING

612.843.6

654. New method of determining illumination required for tasks.

C. L. CROUCH, *Illum. Engng.*, **53**, 416-422 (*August*, 1958).

A study was initiated in 1950 under H. R. Blackwell

at the University of Michigan to re-determine the basic visual performance data necessary to specify illumination recommendations for given visual tasks. This summary of the details of the research project has been prepared in advance of the formal presentation of the results in August, 1958. Essentially, the Landolt ring test object used by H. C. Weston has been superseded by a simple circular disc viewed under threshold conditions. Particular attention is given in the summary to the 56 representative visual tasks against which the results were evaluated. P. P.

612.843.6

655. Recommendations for quality and quantity of illumination.

Illum. Engng., **53**, 422-424 (*August*, 1958).

Prepared by the Quality and Quantity Committee of the American IES, this report describes the derivation of the recommended illumination level for any given visual task from the results of H. R. Blackwell's recent research at the University of Michigan on visual performance. The method involves equating the visual task in question to one of 56 practical visual tasks on which laboratory measurements have been made. The required illumination level is then derived from the brightness required for the rated task and the reflectance for the unrated task. The illumination level is related to 99 per cent accuracy of seeing, to an assimilation rate of five test objects per second and to "moving-eye" field conditions rather than static laboratory viewing conditions. P. P.

656. New footcandle tables. 612.843.6

Illum. Engng., **53**, 425-432 (*August*, 1958).

The 1958 report of the American IES Committee on Quality and Quantity of Illumination has been implemented by the various application committees of the Society to produce new tables of recommended illumination levels. A correlation of the recommendations for similar types of visual task in different fields has been made. The recommendations are derived from H. R. Blackwell's visual performance data, allowance being made for the ability to realise the illumination levels in practice. P. P.

657. An artist looks at gallery lighting. 628.972

E. Warner, *Illum. Engng.*, **53**, 445-450 (*August*, 1958).

The author, a painter-artist, considers, with examples from actual galleries, some of the factors which impair good seeing conditions in art galleries. Paintings should be illuminated by completely diffused light, rather than be picked out by spotlights. Natural daylight is favoured for this purpose. A smooth transition to artificial lighting conditions should be provided. Most pictures should be viewed against a neutral background of 60-65 per cent reflectance. Care should be taken in hanging the pictures to prevent annoying reflections in the picture glazing. Most of these reflections could be overcome by avoiding hanging the pictures high on the walls. P. P.

628.92.96

658. The lighting of modern buildings during the day.

J. Escher-Desrivieres and E. Barthes, *Bull. Soc. Franc. Elect.* (7th Series), **8**, 543-552 (*Sept.*, 1958). *In French.*

Part I examines the daylight illumination conditions of modern buildings and shows that artificial supplementary lighting is necessary and desirable, both to reinforce daylight at the parts remote from side windows where the daylight factor is low, and also on the score of comfort even in new buildings liberally glazed, where venetian blinds are often used to reduce glare from the sun. Supplementary artificial light is also needed where the geometry of the work is unfavourable to daylight, for example in car factories when working under a chassis on an elevated runway. Part II discusses the auxiliary artificial lighting in more detail, giving results of a test in which the number of supplementary lights used by workers on an assembly line is observed and plotted as a function of general illumination. Photoelectric control is recommended, and switching arrangements for the general lighting to enable it to be switched on in part to act as supplementary lighting in daylight. J. M. W.

628.971.6

659. Lighting for traffic using a new type of blended light at the Karlsplatz in Munich.

W. Wehmeyer and W. Schmidt, *Lichttechnik*, **10**, 461-463 (*Sept.*, 1958). *In German.*

At one of the busiest traffic centres in Germany the lighting installation of 25 pairs of 200-watt tungsten lamps, giving an average illumination of about 0.4 lm/ft², has been replaced by 11 large fittings giving over 2 lm/ft². Each fitting contains three 250-watt colour-corrected mercury lamps and three 140-watt sodium lamps so that in the blended light about one-half is from each source. The colour of the light is not unlike that of tungsten lamps but the colour-rendering is markedly inferior. The mounting height is 40 ft. and the spacing of the order of 80 ft. with one extra fitting on the large central island. J. W. T. W.

660. Floodlighting Niagara Falls. 628.971

W. A. Dalrymple and C. A. Albini, *Illum. Engng.*, **53**, 552-556 (*Oct.*, 1958).

The new floodlighting installation at Niagara Falls is described in relation to problems peculiar to the topography of the location. Considerations leading to the decision to use high intensity carbon arcs are referred to, and the choice of projectors, colour filters and electromechanical colour changes are dealt with. P. P.

661. Lighting of galleries in mines. 628.977

H. D. Aberger, *Lichttechnik*, **10**, 513-515 (*Oct.*, 1958). *In German.*

Examines the results of a number of different systems of lighting with fluorescent lamps, especially as regards uniformity of illumination along a gallery. The best conditions are obtained with a reflector fitting giving high intensities up and down the gallery. A system of such fittings, with two 20-watt lamps each and a spacing of 20 metres, gives an average illumination of about 1.2 lm/ft² and a ratio E_{min} : E_{av} = 1 : 8.5. J. W. T. W.

628.93

662. Value of the theory of the light field in practical lighting design.

H. J. Helwig and J. Krochmann, *Lichttechnik*, **10**, 561-565 (*Nov.*, 1958). *In German.*

Attempts have been made by various workers to use as a criterion of quality in interior lighting the so-called "volume illumination" at a point, i.e., the average value of the illumination measured in all directions. As an alternative, the lighting vector in the light field established by the sources has been used. The authors examine both lines of approach, particularly as regards their use for evaluating the various factors which together determine the quality of a lighting system, viz., illumination level, glare, shadow formation and uniformity. They find that the lighting vector is much more limited in its application than the volume illumination. A handy instrument for measuring the latter quantity is described. It consists, in principle, of a photocell inside a small sphere of diffusing glass. The paper includes an extensive bibliography. J. W. T. W.

Discomfort Glare in Interior Lighting Installations—Comparison of Appraisals and Calculated Values*

By E. ROWLANDS, B.Sc., A.Inst.P.

The results of appraisal tests of direct discomfort glare in interior lighting installations are compared with those calculated by the Harrison-Meaker method and by the formula suggested at the CIE meeting in 1955 with terms for the immediate background luminance and the positions of the sources. The comparison shows a marked disagreement for some installations, and suggests that a different approach to the evaluation of direct discomfort glare should be made.

(1) Introduction

In recent years several methods have been suggested for the evaluation of direct discomfort glare in an interior lighting installation. In an attempt to assess the merits of the most popular methods, glare appraisal tests have been conducted and the appraisals of the observers compared with the calculated results. One method of calculation investigated was the Glare Factor method of Harrison and Meaker[1] published in 1947. The other methods used the basic formula suggested at the CIE meeting in 1955[2] with various modifications.

Comparison of glare appraisal test results and Harrison-Meaker Glare Factors have been made previously in America[1] and in Australia[3,4]. A similar comparison was included in the present work in order to cover a very wide range of installations, and to include some with glare factors greater than the maxima encountered in the American and Australian tests (209 and 82 respectively). Further, it was necessary to calibrate the glare factor scale in terms of degrees of discomfort for observers in this country: there were indications that the degree of discomfort corresponding to a particular glare factor would be considered less by observers in this country than in America and Australia.

There does not appear to be any published record of a comparison between appraisals and the glare factors obtained by using the CIE suggested formula.

(2) Details of Installations

The installations selected for this series of tests are described in Table 1.

Installations C and D were in the same room, the end view of the fluorescent lamp fittings being observed in the first case, and the side view for the second: installations E and F were similarly arranged in another room.

All the installations studied were found in offices or factories: none was erected specially for these tests. No installation was completely new and none was in very bad decorative condition.

Figs. 1, 2 and 3 are views of three of the installations from about the observer position used for the "fixed line of sight" appraisal (see section (3)), and are generally typical of those examined.

(3) Appraisal Tests

The observers in the appraisal tests ranged in age from 20 to 60 years and were people who worked in the field of lighting: the majority were concerned with research work, including light sources, and a few were lighting engineers. The number of observers for the first series of tests was eleven: since this number was later felt to be small, it was increased to twenty-six by a second series of tests. Both series covered the same installations, and each ended with a re-appraisal of the first installation in order to see whether there had been a drift of appraisal criterion during the tests. Each series of tests was completed in about three hours.

The observers were asked to estimate the discomfort glare experienced in each installation on an appraisal scale 0-10. The appraisal was recorded with comments on a form which carried the following guide:—

"From the glare point of view,
0 should be regarded as being intolerable,
5 as only just satisfactory and
10 as perfect."

Two values were obtained for each installation. The first one was for a "fixed line of sight," when the observer stood in a definite position looking directly ahead. For the majority of installations, this position of view was a fairly central position at the end of the installation looking in the direction of the rows of fittings: the only exception was that for installation G the position of view was near a corner looking in the direction of a diagonal. The second

* Communication from the staff of the Research Laboratories of The General Electric Company Limited, Wembley, England.

Table 1
Details of Installations

Installation	Type of Fitting	Lamp	Number of Fittings	Arrangement of Fittings (along room)	Mounting Height (ft.)	Size of Room (length × width × height) (ft.)	Illumination on Working Plane (1m/ft²)	General Background Luminance (ft-L)	Immediate Background Luminance (ft-L)
A	Dispersive Reflector (70° cut-off)	300 W Pearl G.S.	8	2 rows of 4	14	40 × 20 × 18	16	5	0.2
B	Deep Bowl Vitreous Enamel Reflector	250 W MBF/U	40	4 rows of 10	12½	120 × 50 × 25	16	2	0.3
C	White Metal Reflector	5 ft. 80 W MCF/U	66	6 rows of 11 (fittings endwise)	10	80 × 56 × 16	21	5	1.3
D	White Metal Reflector	5 ft. 80 W MCF/U	66	11 rows of 6 (fittings crosswise)	10	56 × 80 × 16	21	5	1.6
E	Channel Fitting	5 ft. 80 W MCF/U	76	7 rows of 10 with a row of 6 on outside (fittings endwise)	10	96 × 62 × 16	19	10	1.6
F	Channel Fitting	5 ft. 80 W MCF/U	76	6 rows of 8 on one side 4 rows of 7 on other side (fittings crosswise)	10	62 × 96 × 16	19	10	2.0
G	Deep Bowl Vitreous Enamel Reflector	400 W MAF/V	20	4 rows of 5	14	100 × 80 × 22	15	3	0.8
H	Deep Bowl Vitreous Enamel Reflector	125 W MBF/U	42	6 rows of 7	11	100 × 84 × 15	4	1.5	0.15
I	Opal "Perspex" Trough Reflector	2 5 ft. 80 W MCF/U	24	4 rows of 6 (fittings crosswise)	13½ (but with 5 side fittings at 8½)	57 × 40 × 18	25	12	6
J	Opal Glass Spherical Diffuser	200 W G.S.	8	2 rows of 4	9¼	60 × 25 × 12	10	5	5
K	Channel Fitting	2 5 ft. 80 W MCF/U 1 5 ft. 80 W MCF/U 1 3 ft. 30 W MCF/U	24 in foreground 4 in middle 6 at far end	6 rows of 4 4 rows of 1 3 rows of 2 (all fittings crosswise)	14 8½ 8½	40 × 60 × 14	20	7.5	6

Fig. 1. Installation J.

Fig. 2. Installation H.

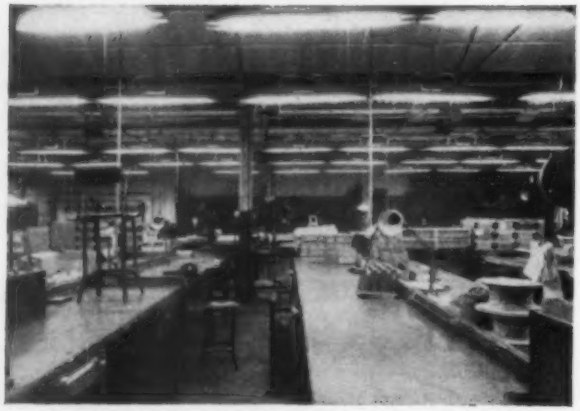


Fig. 3. Installation D.

value was for a "general view" when the observer was asked to walk around in the installation, sit down, perform a task such as using a slide-rule, raise his head to look around the room, continue with his task, and then raise his head again.

The details of the appraisal values and the mean values and spread for each installation are given in the Appendix. The mean values are also recorded in Table 2.

Very little difference was obtained in the values for the first installation when it was re-appraised at the end of the tests: the observers were apparently able to hold their criterion with reasonable certainty.

(4) Calculation of Glare Factors

In each installation, glare factors for each fitting according to the Harrison-Meaker formula and from the CIE suggested basic formula and its variations were calculated for the observer position used for the "fixed line of sight" appraisal, and a simple summation in each case gave the glare factor for the installation. These values are given in Table 2.

Details of the formulae used are as follows:—

(4.1) *Harrison-Meaker Formula*[1]

$$\text{Glare Factor} = \frac{A \cdot B^2 \cdot \text{Location Coefficient}}{h^2 \cdot \text{Surround Factor}}$$

where A = apparent area of source (sq. in.).

B = luminance of source (ft-L divided by 1,000).

h = height of source above observer's eye (ft.).

Location Coefficient takes account of the position of the source relative to the observer.

Surround Factor takes account of the general and the immediate background luminances.

(4.2) *Type of formula suggested at CIE meeting* (1955)[2]

$$\text{(4.2.1)} \qquad \text{Glare Factor} = \frac{B_s^2 \omega}{B_b}$$

where B_s = luminance of source (ft-L.).

ω = solid angle subtended at the eye by the source (steradians).

B_b = luminance of general background (ft-L.).

In addition to applying this formula to all the glare sources in the installation, it was also confined to those sources within 50° of the "fixed line of sight," extending a suggestion by Petherbridge and Hopkinson[5].

$$\text{(4.2.2)} \qquad \text{Glare Factor} = \frac{B_s^2 \omega}{B_b} \cdot \frac{1}{R}$$

This was an attempt to include a term to take account of the immediate background luminance. In the absence of any other published work, the correction factor used by Harrison and Meaker in 1947[1] was adopted and given the symbol "R."

$$\text{(4.2.3)} \qquad \text{Glare Factor} = \frac{B_s^2 \omega}{B_b} \cdot \frac{1}{P^{2.3}}$$

In this formula, the positions of the sources relative to the "fixed line of sight" were considered in the manner suggested at the CIE meeting in 1955[2], "P" being the value of the Position Index used by Luckiesh and Guth in 1949[6].

$$\text{(4.2.4)} \qquad \text{Glare Factor} = \frac{B_s^2 \omega}{B_b} \cdot \frac{1}{R} \cdot \frac{1}{P^{2.3}}$$

In this final formula, the effects of the immediate background luminance and of the positions of the glare sources are brought together.

Table 2
Appraisal and Calculated Values of Discomfort Glare

Installation	Mean Appraisal		Harrison-Meaker Formula	$B_s^2\omega/B_b$		$\frac{B_s^2\omega}{B_b} \cdot \frac{1}{R}$	$\frac{B_s^2\omega}{B_b} \cdot \frac{1}{P^{2.3}}$	$\frac{B_s^2\omega}{B_b} \cdot \frac{1}{R} \cdot \frac{1}{P^{2.3}}$
	"Fixed Line of Sight"	"General View"		All Sources	Sources within 50° of "fixed line of sight"			
F	3.5 (1)	5.5 (1)	1,510 (1)	21,180 (1)	10,020 (1)	35,200 (1)	2,660 (1)	4,420 (1)
K	5.5 (2)	7.0 (7)	330 (3)	8,660 (2)	5,850 (3)	9,220 (4)	912 (2)	970 (2)
J	6.0 (3)	6.2 (4)	86 (6)	1,390 (10)	1,390 (9)	1,390 (10)	374 (7)	374 (6)
A	6.6 (4)	6.0 (3)	43 (8)	2,100 (9)	2,100 (8)	820 (11)	613 (3)	248 (7)
G	6.8 (5)	6.7 (6)	104 (5)	4,770 (6)	4,770 (5)	7,460 (6)	329 (8)	514 (5)
H	6.8 (6)	6.2 (4)	8 (11)	3,890 (7)	160 (11)	7,470 (5)	29 (11)	56 (11)
E	6.9 (7)	5.5 (1)	391 (2)	5,820 (5)	3,560 (6)	10,220 (3)	490 (6)	860 (4)
B	7.0 (8)	7.1 (8)	170 (4)	7,120 (4)	6,880 (2)	12,500 (2)	506 (4)	889 (3)
C	7.7 (9)	8.1 (9)	57 (7)	8,520 (3)	5,180 (4)	3,650 (7)	499 (5)	222 (8)
D	8.2 (10)	8.1 (9)	31 (10)	965 (11)	790 (10)	1,400 (9)	82 (10)	119 (9)
I	8.7 (11)	8.5 (11)	38 (9)	3,760 (8)	3,080 (7)	1,750 (8)	202 (9)	102 (10)

(5) Discussion of Results

(5.1) "*Fixed Line of Sight*" *Appraisals*

The installations are listed in Table 2 in the order of increasing value on the appraisal scale for the "fixed line of sight," i.e., decreasing discomfort glare. The numbers in brackets in the other columns give the order in that column of decreasing discomfort glare. It can be seen that there are some serious discrepancies between the appraisal and calculated values and also between the values calculated by the different methods, particularly in the order of decreasing discomfort glare formed by the values. This can be seen more clearly from Figs. 4 and 5 where the values have been plotted against the installations arranged in increasing order of value on the appraisal scale ("fixed line of sight"): an attempt has been made to match the appraisal and calculated scales. Some installations which belong, according to the appraisals, either to the high or the low discomfort glare groups (F, K, J and C, D, I respectively) are displaced from their group by the calculated values. Further, in the middle group of installations (A, G, H, E, B) where the discomfort glare appraisal is nearly constant, the calculated glare factors vary enormously. In some instances, as in the case of installation H, the discrepancies are great and a very large change would be required in the formulae to obtain good agreement.

From an examination of the results and in particular Fig. 5, it appears that a method for the successful evaluation of discomfort glare cannot be very simple and must include the influences of the immediate background luminance and the positions of the sources.

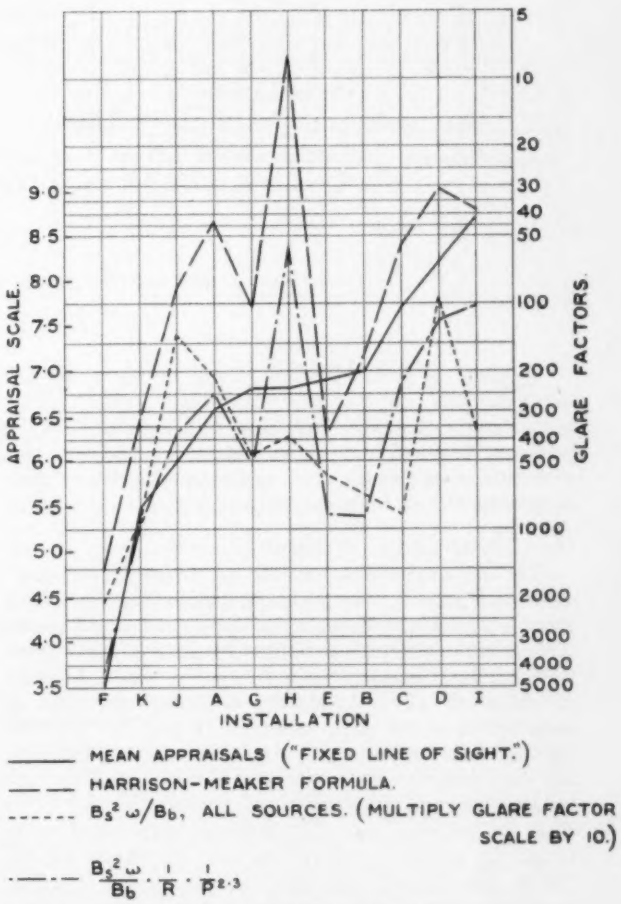


Fig. 4. Comparison of discomfort glare appraisals (fixed line of sight) with values calculated by three methods.

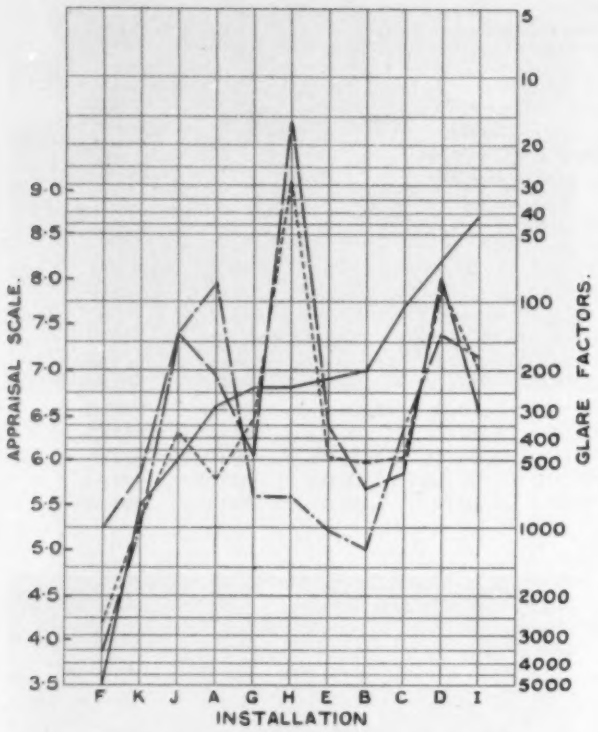

APPRAISAL SCALE.
GLARE FACTORS.
INSTALLATION
F K J A G H E B C D I
MEAN APPRAISALS ("FIXED LINE OF SIGHT")
$B_s^2\omega/B_b$, SOURCES WITHIN 50° OF "FIXED LINE OF SIGHT" (MULTIPLY GLARE FACTOR SCALE BY 10).
$\frac{B_s^2\omega}{B_b}\cdot\frac{1}{p^{2\cdot3}}$
$\frac{B_s^2\omega}{B_b}\cdot\frac{1}{R}$ (MULTIPLY GLARE FACTOR SCALE BY 10).

Fig. 5 (left) Comparison of discomfort glare appraisals (fixed line of sight) with calculated values showing influence of immediate background luminance and of position of sources on simplified formula.

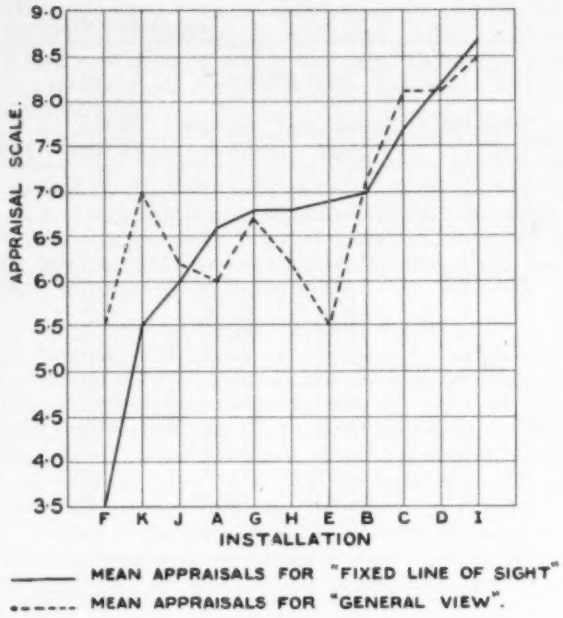


Fig. 6 (above) Comparison of discomfort glare appraisals made for "fixed line of sight" and for "general view."

A study of corresponding values, in Fig 4, on the appraisal and on the Harrison-Meaker Glare Factor scales, and a comparison of them with the results of the previous tests referred to in section (1), indicate that observers in Britain are more tolerant of discomfort glare than observers in America and Australia.

(5.2) "*General View*" *Appraisals*

The mean appraisals for both the "fixed line of sight" and the "general view" are plotted in Fig. 6. While there is a similarity between the values and also between their order of decreasing discomfort glare in some cases, there are bad discrepancies in others. A major difficulty in obtaining good agreement concerns one pair of installations in the same room, viz. E and F. Whereas for the "fixed line of sight" the values are very different, for the "general view" the same value applies to both installations, and is between the other two values. (This effect for the other pair of installations in the same room, C and D, is not so marked because the values for the "fixed line of sight" are fairly close together). Further, an examination of these appraisal values for the "general view" shows that no better agreement is obtained with the calculated values. It is, therefore, doubtful whether a "fixed line of sight" study from an end of an installation is the most suitable method of evaluating the discomfort glare to be experienced in that installation.

(6) Conclusion

The formulae investigated do not give a result which agrees well with the observed discomfort glare, and the anomalies obtained are so large in some installations that minor changes to the formulae, such as changes in the exponents of the CIE suggested formula, will not give any better agreement. To obtain an improvement it is felt that a different approach to the evaluation of discomfort glare in an interior lighting installation will have to be made.

References

(1) W. Harrison and P. Meaker, *Illuminating Engineering*, **42,** 153 (1947).
(2) Proceedings, Commission Internationale de l'Eclairage, 13th Session, Zurich (1955).
(3) J. C. Lowson, A. Dresler and S. Holman, Supplement to the *I.E.S. Lighting Review* (Australia), p. 13, April 1952.
(4) J. C. Lowson, A. Dresler and S. Holman, *Illuminating Engineering*, **49,** 497 (1954).
(5) P. Petherbridge and R. G. Hopkinson, Trans. Illum. Eng. Soc. (London), **15,** 39 (1950).
(6) M. Luckiesh and S. K. Guth, *Illuminating Engineering*, **44,** 650 (1949).

APPENDIX

Details of Appraisal Values

The validity of the comparison between the observed and calculated values depends greatly on the agreement between the observers' appraisals. Detailed appraisal values are given in Table 3: they indicate that a fair measure of agreement was obtained, and that the spread was small for the majority of installations.

Notes

(1) The table gives the number of each appraisal value recorded per installation.

(2) The observers were asked to use, if possible, the integers on the scale 0-10 for their appraisals: however, if it was necessary to use more divisions, those of a half could be used. In the table, an appraisal value involving a half has been recorded by increasing the number of appraisals for the integers immediately below and above it by a half.

(3) A_1 refers to the appraisal of installation A at the beginning of the tests, and A_2 to its re-appraisal at the end (see section (3)).

Table 3
Installation Appraisal Distribution

Installation	Appraisal Scale Values											Mean Value	Standard Deviation
	0	1	2	3	4	5	6	7	8	9	10		
"Fixed Line of Sight"													
A_1	0	0	0	1	2	1	8	7	6	0	1	6.6	1.4
B	0	0	0	0	1	1½	3½	12	7	1	0	7.0	1.0
C	0	0	0	0	0	2	1	9	7½	5	1½	7.7	1.2
D	0	0	0	0	0	1	2	3½	7	10½	2	8.2	1.2
E	0	0	0	0	2	1½	6	6	8½	2	0	6.9	1.3
F	½	2½	3	8	8	0	2	1	1	0	0	3.5	1.6
G	0	0	0	0	3	0	4½	10½	7	1	0	6.8	1.0
H	0	0	1	1	1	0	7	6½	5	4	½	6.8	1.3
I	0	0	0	0	0	0	1	0	9	13	3	8.7	0.7
J	0	0	0	1	5	2	7	8½	1½	1	0	6.0	1.3
K	0	0	0	1	8	6	4	3½	3	½	0	5.5	1.3
A_2	0	0	0	0	3	2½	7½	5	6	1	1	6.6	1.5
"General View"													
A_1	0	0	1	0	2	7	4½	6½	3	1	1	6.2	1.5
B	0	0	0	0	0	0	7½	11½	5	1	1	7.1	1.0
C, D	0	0	0	0	0	0	3	4½	10	5	3½	8.1	1.2
E, F	0	0	1	2½	2½	8½	4½	4	2½	½	0	5.5	1.5
G	0	0	0	1	1	2½	4½	11	3½	2½	0	6.7	1.3
H	0	0	2	0	2	5	5	5	4	3	0	6.2	1.7
I	0	0	0	0	0	0	1	1½	10½	10	3	8.5	0.8
J	0	0	0	2	2	3	7	7	4	1	0	6.2	1.4
K	0	0	0	0	0	4½	4½	7½	6½	3	0	7.0	1.3
A_2	0	0	0	3	3	5½	4	4½	5	1	0	5.9	1.5

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ADASTRA CONCORD COLUMN

for Group 'B' Lighting

DESIGN

A graceful, slender tapering column which quickly dissolves into the background.

ERECTION

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PROTECTION

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I.E.S. ACTIVITIES

London

At the meeting held on January 13th Mr. J. M. Waldram gave a paper entitled "The lighting of Gloucester Cathedral by the 'Designed Appearance' method."

The relighting of Gloucester Cathedral, said Mr. Waldram, provided a unique opportunity for the method recently developed known as "Designed Appearance" lighting. In this method the design commences with the appearance of the lighted interior, in terms of distribution of brightness and of modelling, and the lighting scheme is calculated to produce these effects. The method is valuable even in an existing building, since the electrical distribution can be confidently planned from an early stage.

Gloucester Cathedral is a traditional stone building in several styles; the greatest contrast is between the Norman nave and the beautiful Perpendicular choir and transepts. There are five separated spaces which provide vistas from one to another. The surfaces are often elaborately moulded, which endows them with unusual reflecting properties. These and other features presented new problems.

The first step was to become familiar with the building from drawings and photographs, and then to form an idea of the possible final appearance, along with the possible lighting system. For several reasons, a concealed system was preferred. Sketches were made of the interior as it might appear, and the proposed appearance written down in general terms. These were revised after visits and discussions, and the scheme was calculated, at first approximately using modified flux methods, from which a provisional specification was drawn up. Detailed calculation followed, and the final specification was drawn showing for each unit its site, equipment, lamp, louvres or spreaders and direction of aim, all calculated from the drawings. Special equipment was designed to facilitate erection, aim and maintenance. The lighting of each space was checked by trial, to verify the specification of brightness and the calculations, and for final approval. Only minor modifications were needed from the calculated scheme, and the results agreed satisfactorily with the requirements.

Throughout the building directional effects were carefully maintained. Light was arranged to come generally from the south, with local modifications, to reveal the architectural forms naturally. The design of the building imposed some conditions for which no satisfactory compromise was possible, but the equipment is so placed that persons entering the Cathedral and worshipping there do not notice it.

The aim of the lighting scheme was to reveal the architecture so that it plays its proper part as an aid to worship but without overemphasis, and to bring to this very beautiful building the resources of the present century if possible as its builders would have done had they had them at their disposal.

Leicester Centre

At the meeting of the Leicester Centre on January 26th the speaker was Mr. R. H. Saunders, whose subject was "Industrial Lighting."

The paper described the changes in industrial lighting practice in both light and heavy engineering industries since 1948. Mr. Saunders also referred to the great advancement in light source efficiencies and the improved lighting equipment. Statistics proved beyond doubt that the fluorescent lamp was the most efficient light source both from the economic and the light output point of view. The 8-ft. 125-watt fluorescent lamp was becoming increasingly popular particularly for high bay lighting. Trunking systems in which power and other electrical services could be installed was being used extensively and was proving a most satisfactory method of industrial lighting.

Special reference was made to factors affecting efficiency, maintenance, and safety and also to specially designed equipment for dusty, corrosive, and hazardous areas with specialised fittings to suit the particular conditions. Over the subject of exterior lighting, Mr. Saunders referred to the very successful use of high tower lighting by nationalised industries like the Coal Board and British Railways where towers 150 ft. high in which batteries of high wattage lamps were installed to illuminate railway sidings and marshalling yards.

At the conclusion of the lecture, there was a discussion in which a number of members took part.

Sheffield Centre

The Sheffield Centre had a gathering of some 50 members and friends at their third sessional meeting on December 8th to hear a lecture given by Miss Jean L. Stewart on Display Lighting. The lecture was supported by a large amount of apparatus and a demonstration shop window.

The lecturer commenced by discussing the power of light to attract and suggested that, though we may deplore the fact, to some people glare can act as an attraction. Under some circumstances lighting engineers are torn between good lighting practice and the desire to honestly interpret the client's wishes.

A factor all too frequently overlooked in shop design is the lighting of vertical surfaces. The illumination levels quoted are almost inevitably those on the horizontal plane and yet the shopkeeper is not selling the floor, his counter top or even the bed of the window. The over-all-light ceilings covering shop windows give a beautiful over-all illumination—but where? To most people a window display is a picture set at a few degrees off the vertical and so the goods towards the front of the window receive little or no illumination. Further behind conditions are better, but particularly in a shallow window with a light coloured background, the back of the window is often the brightest thing in the customers' field of view, making the goods in front appear in silhouette.

In conclusion after demonstrating many of the variations on lighting jewels, examples were given of interiors with particular reference to awkward ceiling structures, shape of shop, layouts and openbacked windows including the new problem of self-service stores.

There was an enthusiastic discussion afterwards led by representatives of many of the large stores present who took a great interest in the problem of colour rendering.

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At its Sessional Meeting on December 8th the Leeds Centre was privileged to receive the first presentation of a paper entitled "Lighting Calculations for Linear fittings from Polar Curves." The author of the paper, Mr. R. R. Holmes, introduced his subject by stating that it was a practical approach to an ever-recurring problem—that of obtaining an acceptably accurate answer to the direct illumination received from a single unit or group of tubular fluorescent fittings.

The method, which is equally applicable to fittings of widely different distribution characteristics, could be applied to reference planes in the horizontal, vertical or any intermediate angle. The lighting engineer would be supplied

continued at foot of page 110

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ELECTRICAL ENGINEERS

(A.S.E.E.)

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STREET LIGHTING and LIGHTHOUSE equipment features

Also see:

THE WORLD'S LARGEST ELECTRIC CLOCK

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Swan Anniversary Lecture

One of the first major items in the Golden Jubilee year programme of The Illuminating Engineering Society was the Swan Anniversary Lecture arranged on February 3rd by the Newcastle Centre of the Society and held at the Literary and Philosophical Society in Newcastle where 80 years to the day Swan first demonstrated his carbon filament electric lamp. The lecture was given by Dr. J. N. Aldington, a past president of the Society and Managing Director of Siemens Edison Swan Ltd., and was entitled " Sir Joseph Swan and the evolution of the electric lamp." It was a very successful occasion and gave an excellent start to the year's activities. The lecture attracted considerable notice in the Press and on radio and television. There was an audience of over 500 people.

The proceedings were opened by the President of the Society, Mr. C. C. Smith, who briefly recalled the objectives of the Society during its Jubilee year. He then introduced the chairman for the evening who was none other than the son of Joseph Swan, Sir Kenneth Swan, Q.C. Sir Kenneth and Lady Swan had made a special journey to Newcastle to be present at the lecture. In a brilliant introduction Sir Kenneth recalled that though he was only two years of age at the time his father first publicly demonstrated his electric lamp he well remembered living at Gateshead and much of his father's work. He spoke of his great pleasure at being invited by the IES to take part in the evening's proceedings and at being present in " this historic room."

Dr. Aldington in his lecture dealt with Joseph Swan's early life in Sunderland and his many interests, including his contributions to photography and in the production of an early form of artificial silk. Swan, who worked by day as a druggist in Newcastle, worked alone on these things as a hobby at his home in the evenings. It was in this way that he produced his electric lamp. At the same time Edison in the USA was also working on the electric lamp with a staff of 80 or more assistants in his laboratory. Edison was more of a business man than Swan and foreseeing the great future of the electric lamp, as he made each individual development he took out a patent for it both in the USA and in England. Swan, however, was too modest to take similar steps with the result that until now Edison had been regarded by most people as the inventor of the first carbon filament electric lamp. From his detailed examination of the facts, Dr. Aldington said it was clear that Swan was working on the problem of producing a hermetically sealed bulb in which an electric conductor capable of being heated to a white heat by the passage of electric current would be mounted, long before Edison started to think of such a lamp. The first patent was Edison's—but the first invention beyond all doubt was Swan's. Dr. Aldington pointed out, however, that it was not long before these two great men came together and their names were joined in one company to produce the best lamp from their joint efforts. The lecture was illustrated with a number of demonstrations on Swan's experiments.

Sir Kenneth Swan and Dr. Aldington with Swan's original lamp

A vote of thanks to both Sir Kenneth Swan for taking the chair and to Dr. Aldington for his lecture was proposed by Dr. J. W. T. Walsh, a past president of the IES and President of the International Commission on Illumination.

This lecture has undoubtedly set a very high standard for other events during the months to come and all who took part in the organisation are to be congratulated. The sub-committee of the Newcastle Centre which arranged the lecture acted under the chairmanship of Mr. J. S. McCulloch. Mr. H. W. Cumming, of Siemens Edison Swan, was responsible for the stage management of Dr. Aldington's demonstrations. The audience included the Lord Mayor of Newcastle, the Mayors of Gateshead and Sunderland, the Rector of King's College, Durham University, and many distinguished representatives of other societies. On view both before and after the lecture was a display of lamps including Swan's original lamp.

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with tables of Aspect Factors (derived from, and related to, the fitting under consideration) and specimen tables were made available at the meeting.

Mr. Holmes stated that he had carried out a number of tests on actual installations which showed the " Aspect Factor " method to be quite acceptable. In applying it, however, the engineer must remember that in addition to the calculated direct component an estimation must be made of the flux contributed by inter-reflections.

The discussion was opened by Mr. D. R. Griffiths and a vote of thanks, proposed by Mr. H. Laycock was heartily endorsed by the appreciative and attentive audience.

The Centre meeting on January 12th took the form of a " Forum on Home Lighting," the panel consisting of Councillor Mrs. B. M. Garden (housewife), Mr. M. L. Berson (ophthalmic optician), Mr. G. A. Farthing (Yorkshire Electricity Board), Mr. E. Milner (lighting engineer) and Mr. S. F. Speight (lighting fittings manufacturer).

The large and appreciative audience kept the panel busy with such questions as " What levels of illumination should be employed in domestic interiors, (a) with fluorescent lamps, (b) with tungsten lamps ? " and " Is the panel satisfied with the design of domestic lighting fittings from a functional and an æsthetic point of view ? "

Under the excellent chairmanship of Dr. D. L. Smare, who sometimes had to frame questions out of lengthy statements by members of the audience, the panel produced the following points among their many answers:

Most domestic lighting schemes are arrived at by accident—but are generally quite satisfactory because the unsuccessful schemes are very soon rectified;

The use of pink-tinted lamps follows the lead given by

many decorative shade designers, who had for some time been introduced pink into the shade itself;

The main disadvantage with the use of fluorescent lamps in the kitchen is that they tend to show up the dirt too much;

Domestic lighting layouts are still tied to the " gas age ";

The design of domestic lighting fittings is entering upon a second Elizabethan age just as exciting as the original.

Birmingham Centre

The bienniel display of lighting equipment arranged by the Birmingham Centre has become so popular that more accommodation was required this year, and the meeting on January 2nd was held at the new Bennett Hall, Y.M.C.A. Building, Snow Hill, Birmingham.

Sixteen manufacturers of lighting equipment participated, and in accordance with the rules of the display, each exhibitor, presented four pieces of lighting equipment developed during the past two years and were allowed four minutes in which to address the assembly on the merits of their exhibits. The British Lighting Council showed some recent lamp developments, and on the eighteenth stand, the Society featured a map of the world, showing the widespread membership of the Society, and a brief address on its ramifications by Mr. E. Kemp, chairman of the membership committee of the Centre.

Mr. L. Gibbs, Chairman of the Centre, opened the meeting, the exhibitors proclaimed their exhibits and Mr. H. J. Gibson, Chief Commercial Officer of the Midlands Electricity Board, started the discussion. The meeting was then thrown open for everyone to inspect the fittings on view:—street lighting lanterns, industrial, commercial and domestic fittings, mine lighting equipment, fittings to modular dimensions, luminous and louvred panels, fittings for tungsten, mercury and sodium lamps and fluorescent tubes of many lengths—the variety was as wide as application demands.

This is probably the only periodical display in the country where the most modern lighting equipment can be seen and debated upon in a way which enables those interested to appreciate the trend in manufacturers design in all classes of fittings. Attendance was greater than ever, and as many members from London, as well as other provincial centres, were present, it is obvious that this display is a major attraction in the lighting world, and further displays in later years will continue to draw the attention they deserve.

The Lord Mayor of Birmingham, Alderman D. Johnstone, with Mr. L. E. Gibbs (chairman) and Mr. N. Boydell (vice-president) at the Annual Dinner of the Birmingham Centre held in January.

FORTHCOMING EVENTS

LONDON

March 10th

LONDON.—" Permanent Supplementary Artificial Lighting in Buildings," by R. G. Hopkinson and J. Longmore. (At the Royal Society of Arts, John Adam Street, W.C.2.) 6 p.m.

CENTRES AND GROUPS

March 2nd

STOKE-ON-TRENT.—" Lighting and Industry in the Soviet Union," by E. H. Norgrove. (At the North Stafford Hotel, Stoke-on-Trent.) 6 p.m.

March 4th

EDINBURGH.—" Lighting and Safety in Building Operations and Works of Engineering Construction," by J. Gordon Scott. (At Y.M.C.A., 14, South St. Andrew Street, Edinburgh.) 6.30 p.m.

March 5th

CARDIFF.—" Lighting for Display," by H. H. Ballin. (At the Demonstration Theatre, South Wales Electricity Board, The Hayes, Cardiff.) 6 p.m.

GLASGOW.—" Lighting and Safety in Building Operations and Works of Engineering Construction," by J. Gordon Scott. (At the British Lighting Council, 29, St. Vincent Place, Glasgow.) 6.30 p.m.

NOTTINGHAM.—" The Lighting Installations at the Nottingham and District Technical College," by P. A. Moore. (At the Electricity Service Centre, Nottingham.) 6 p.m.

March 6th

BATH and BRISTOL.—Annual Dinner and Dance. (At the Hawthorns Hotel, Bristol.)

CARDIFF.—" Lighting for Display," by H. H. Ballin. (At the Demonstration Theatre, South Wales Electricity Board, The Hayes, Cardiff.) 6 p.m.

March 9th

SHEFFIELD.—Visit to Industrial Installation at Samuel Fox and Co., Stocksbridge Works, 6.30 p.m.

March 12th

MANCHESTER.—" Lighting in Commerce," by K. C. White. (At the North Western Electricity Board, Town Hall Extension, Manchester.) 6 p.m.

March 16th

BATH and BRISTOL.—" Airport Lighting," by J. G. Holmes. (At Gardner Sons and Co. Ltd., Showroom, Broad Plain, Bristol.) 7 p.m.

March 17th

LIVERPOOL.—" Some Advances in Materials for Lighting, 1909-1959," by W. E. Harper. (At the Merseyside and N. Wales Electricity Board Industrial Development Centre.) 6 p.m.

March 18th

NORTH LANCASHIRE.—Annual General Meeting. " Commercial and Industrial Lighting," by A. Temple. (At the Demonstration Theatre, North Western Electricity Board, 19, Friargate, Preston.) 7 p.m.

TEES-SIDE.—" Lighting in 1984," by E. E. Miles. (At the Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough.) 6.30 p.m.

March 20th

BIRMINGHAM.—"Architecture of Light," by Rolf Helburg. (At St. Mary's Hall, Coventry.)

March 23rd

LEICESTER.—" An Architect looks at Lighting," by S. Penn-Smith. (At the Demonstration Theatre, East Midlands Electricity Board, Charles Street, Leicester.) 7 p.m.

March 24th

LEEDS.—" Fifty Years of Lighting Development," by J. W. Howell, Joint Meeting with the IEE. (At the Institute of Technology, Bradford.)

POSTSCRIPT By 'Lumeritas'

TO the uninitiated it must appear that one of the oddest technical terms in the lighting vocabulary is *foot-lambert*. There is nothing very unusual about naming units after men. We are so accustomed to *volts*, *amperes* and *ohms* that we seldom think of these words as personal names—they might as well be invented terms. But somehow it seems less easy not to think of a person rather than a unit of luminance when the term *lambert* is used. However, if the names of Volta, Ampere and Ohm can be immortalised as technical terms, there is really no reason why Lambert's name should not be similarly treated. But, *foot-lambert*; ugh! Thank goodness we don't have *foot-volts*, *foot-amps* and *foot-ohms* too. Although *lumen* was not derived from a family name, believe it or not, there was a Devonshire family who bore this name although it came to an end nearly 700 years ago. Sir William Lumen—the first of the family of which any record survives—was born in the reign of King John and, aptly enough, his arms were "a sun in his splendour" on a red escutcheon. I am not well versed in heraldry but, if "pink hand" is substituted for "red escutcheon" we come down the ages to the rather cryptic symbol adopted by the IES for its Golden Jubilee year. The permanent insignia of the Society (see p. 55 of this journal last month) is—also aptly—a sun in his splendour encompassing his man-made substitute—a flambeau—seen against a blue sky and supported by the heads of two British lions. However, to come back to the real topic of this paragraph, isn't it a pity that we can't find some more attractive term for what we mean by *foot-lambert*? We won't adopt the metric system so we can't use *milli-lambert*. But I like milli-lambert: I could fall for her, couldn't you? However, I don't like all her metric relatives. A short time ago a medical friend who wanted to measure luminance at the eye asked me about units of brightness. I showed him a publication in which these units are named and defined. When he found *nit* among them I'm afraid—to use a contemporary vulgarism—he laughed like a drain! Wouldn't you?

ON previous occasions I have made slight reference to the "Hawthorne Studies" made by Dr. Elton Mayo of Harvard in one of the works of the Western Electric Company of America. These studies were made between the years 1927 and 1936 and they have attained "classics" status among the great number of studies which have been undertaken since World War I to ascertain how human industrial efficiency is affected by working conditions. The reason why so much importance it attached to them is that they showed very clearly that if workers know that management has their welfare at heart, and is trying to find out how best to secure it, the satisfaction which this interest affords can lead to increased productivity in spite of adverse conditions. This is part of the explanation of Elton Mayo's seemingly paradoxical finding that production went up not only when the lighting was experimentally improved but also when it was experimentally worsened. I am told that someone at New York University who is now engaged in tracing the history of the Hawthorne experiments has found that Elton Mayo's studies were prompted by the results of Weston and Taylor's investigation in our own country of the relation between illumination and typesetting by hand, which were published in 1926. It may be interesting, also, to note that owing to the much more recent publication of Weston's data on the relation between size, brightness contrast, illumination and visual efficiency, "The Weston system provided the (American) Society in the Post-World War II period with a method of determining the footcandles of illumination needed for various field tasks" (*vide*, Illuminating Engineering, August, 1958, p. 416), and then prompted the American Society to commission Dr. H. R. Blackwell to evolve an alternative system which he is to describe to the CIE at Brussels in June.

ONE of the most notable of the 19th century essayists, R. W. Emerson, once wrote that "gaslight is the best nocturnal police". He was referring to street lighting by gas, which was an innovation in his time and one that did undoubtedly make the nefarious activities of the footpad less easy to carry on with impunity. Nowadays there is so much emphasis put upon the accident reducing function of street lighting that we think less of the relative freedom from molestation by thugs which we enjoy owing to modern street lighting. I say "relative freedom" advisedly because, of course, street robberies with violence do still occur at night (and by day), though the risk of sustaining such an experience is undoubtedly less than when the common obscurity of ill-lighted streets gave ample cover to lurking rapscallions. Nevertheless, we still have many poorly lit streets and public places some of which—not surprisingly—are the haunts of such as hope to prey upon their fellow citizens in one disreputable way or another. Thus, the Minister of Works was recently asked to consider installing better illumination in Hyde Park in the interests of the maintenance of public order. He replied that 23 additional lamp standards had been installed last summer and the police informed him that this had resulted in a marked improvement. But, although Emerson might have said "electric light is the best nocturnal police" had he lived in our time, apparently there is still today a high regard for gas lighting in Emerson's country—the U.S.A. According to a trade survey published a few weeks ago, gas lighting has made a remarkable come-back throughout the United States. In Edison's home town—Orange, New Jersey—the streets are still lit by gas lamps and these are to be retained, including those in front of Edison's home.

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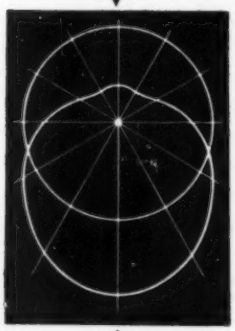

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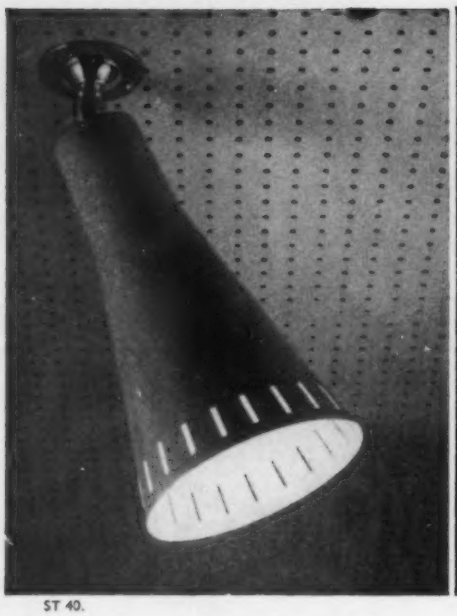

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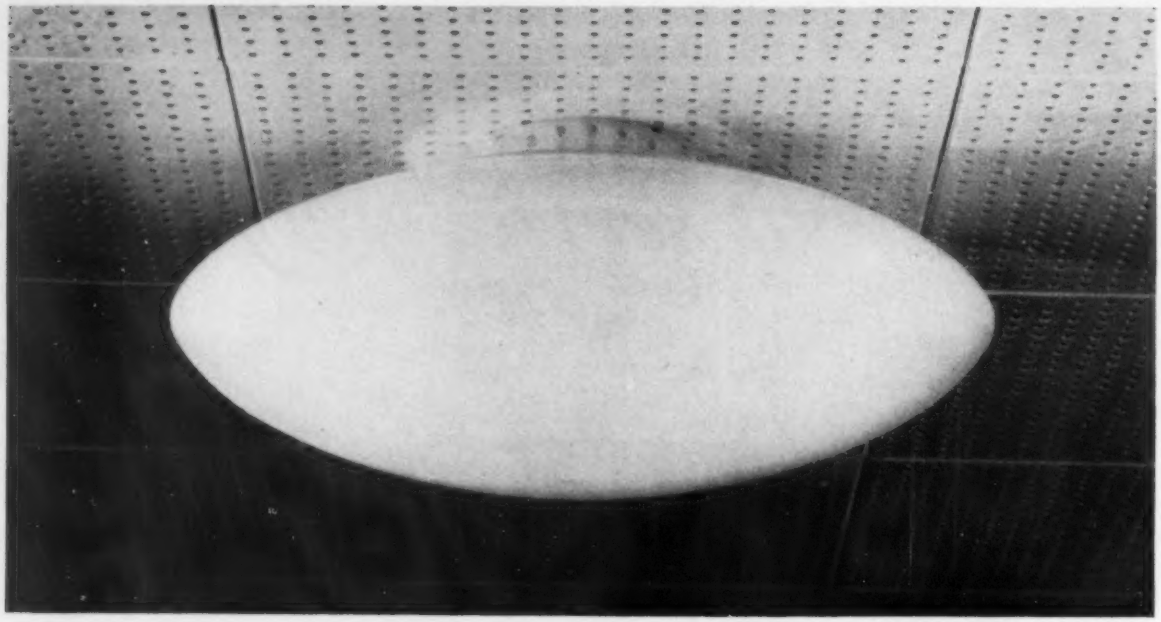

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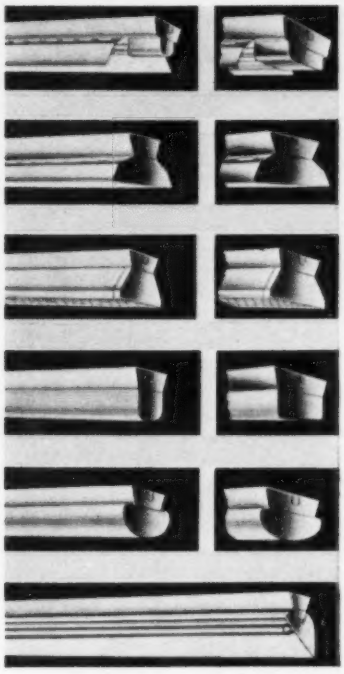

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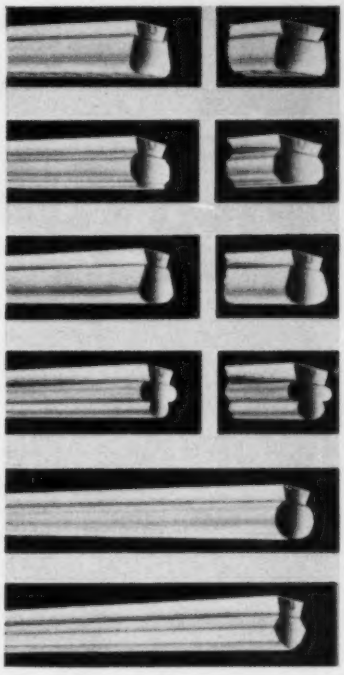

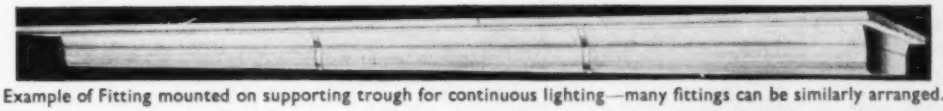

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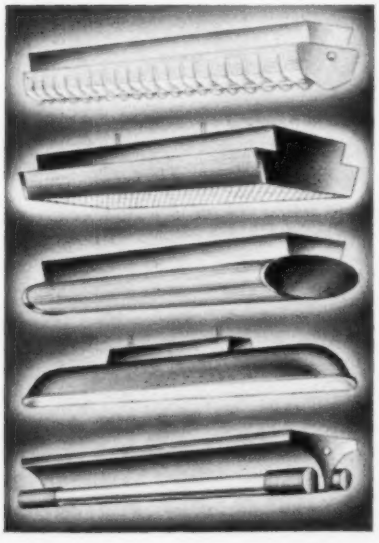

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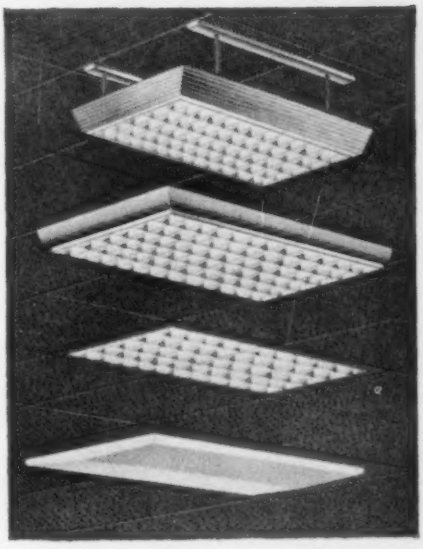

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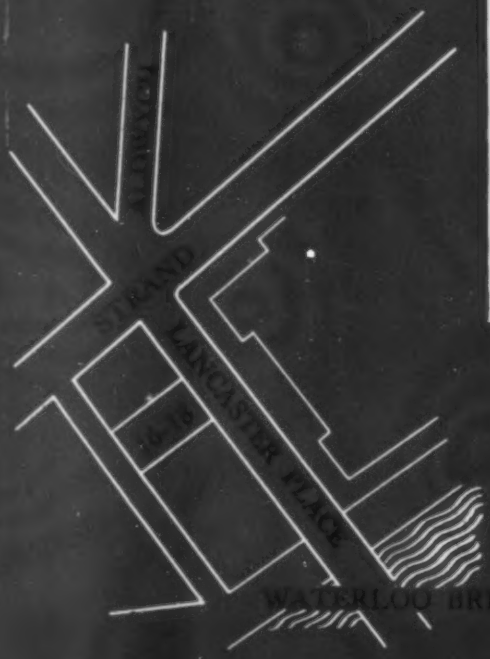

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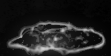
above: *A general view of the new centre, including one of the demonstration windows in the Shop section, the illuminated fireplace, with its transparent mirror, in the Domestic section, and at higher level part of the cornice comparing the effects of the six standard colours of fluorescent tube.*